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CHARACTERISTICS OF A SAMPLE OF COTTONTAIL RABBIT HUNTERS IN EASTERN NEW YORK[1]

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ABSTRACT

During a 5-year study in Albany, Columbia and Rensselaer Counties over 200 hunters provided information pertaining to nearly 3,300 cottontail hunts. The "average" hunter made about eight hunts annually throughout the 4½-month season, mostly on weekends. Each hunt lasted about 3¼ hours during which time he and one companion saw four cottontails and took two, requiring approximately 4 man-hours for each rabbit bagged. When hunting with dogs his hunts were longer, and he saw and took more rabbits. On an hourly basis, however, his take was at least as high without dogs. In relation to hunting regulations, the findings indicate that those in effect during the study afforded a high degree of hunting opportunity and had no adverse effect on cottontail abundance.

An important consideration in evaluating the effectiveness of harvesting regulations for game is the degree to which available hunting opportunity is utilized. Currently, open seasons and bag limits for cottontail rabbits (*Sylvilagus floridanus*) vary considerably among the northeastern states. Regulations in New York are among the most liberal in the region. In recent years approximately 250,000 hunters (half the licensed small game hunters in the State) have taken from 1.5 to 2.5 million cottontails each season. The purpose of this paper is to present data for a 5-year period relating to the characteristics of a sample of cottontail hunters who pursued their sport in a three-county area in eastern New York. Over 200 hunters provided information pertaining to nearly 3,300 cottontail hunts during the course of this study. The findings are appraised as they relate to current cottontail harvesting regulations in New York.

[1] A contribution of Federal Aid in Fish and Wildlife Restoration Project W-84-R. The study was begun under Joseph Dell, former leader of the project. The authors also gratefully acknowledge the assistance of the following: Joseph C. Bursey and George H. Teidman for aid in many phases of the study; H. F. Maguire for providing unpublished results of the small game take survey; Rollo Davenport of the Division of Motor Boats of the Conservation Department for machine tabulations of data; Catherine Dennis and Carol Plominski for help in preparing data for tabulation; and finally, to the many sportsmen whose cooperation made this study possible.

METHODS

Information was obtained from volunteer cooperators in an attempt to measure annual variations in cottontail abundance as reflected by hunter success. Cooperators were solicited through contacts with sportsmen's groups and individual hunters, and through Department announcements in various news media. The study began in the 1956–57 season.

The Study Area

The study was limited to Albany, Columbia and Rensselaer Counties in eastern New York (Figure 1). The major portion of the three-county

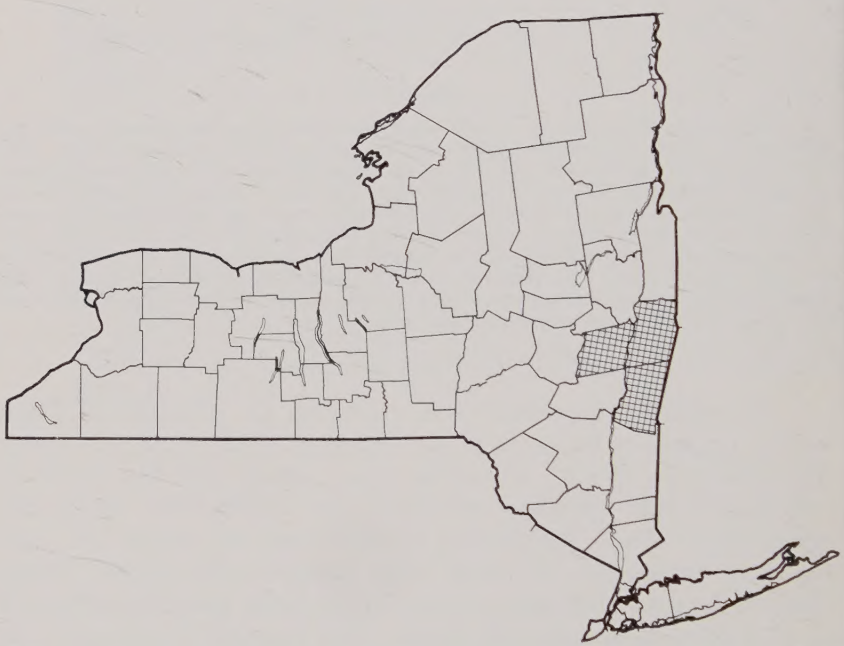

Figure 1. Location of Albany, Columbia and Rensselaer Counties.

area is within the Hudson Valley ecological zone. A varied agriculture and urban and suburban developments constitute the principal forms of land use. The cottontail rabbit is the most numerous and readily available game animal. The southwestern portion of Albany County and the eastern parts of Columbia and Rensselaer Counties are of higher elevation and more wooded terrain. Cottontails are found there also but are less abundant; deer and grouse (and varying hare, in some places) are more typical species. According to the annual small game take survey[2], approximately half of the 10,000 small game licensees within

[2] Conducted under Federal Aid in Fish and Wildlife Restoration Project W-90-R

the area hunt specifically for cottontails, and cottontails represent the major game species in a large portion of it.

COLLECTION OF DATA

During the first four years of the study cooperators were provided with booklets in which to record their cottontail hunts for the entire season. The following information was requested for each hunt: date; location (county and nearest village); hours afield (to the nearest ¼ hour); number of hunters and dogs involved; number of rabbits seen, number wounded and escaped, and number taken (by sex); and remarks.

In the 1960–61 season the reporting system was changed somewhat. In place of season booklets, cooperators were mailed monthly record forms (on double postcards) prior to each month of the season. Attached was a reminder to submit records for the previous month. The objective was to obtain greater response as well as more accurate records. On the monthly cards cooperators were no longer requested to provide information regarding wounded and escaped cottontails or the sex of those taken. They were, however, asked to note the number of rabbits "started" by dogs as well as those seen.

HUNTING REGULATIONS

During this study the open season for cottontails averaged 19 weeks (133 days), beginning in mid- or late October and extending through February (Table 1). The daily bag limit was six with no restriction on

TABLE 1. HUNTING REGULATIONS FOR COTTONTAIL RABBITS IN ALBANY, COLUMBIA AND RENSSELAER COUNTIES, 1956–57 TO 1960–61

Season	Dates of season		Number of days		Daily bag limit
	Opening	Closing	Total	Weekend	
1956–57	October 15, 1956	February 28, 1957	137	37	6
1957–58	October 14, 1957	February 28, 1958	138	38	6
1958–59	October 16, 1958	February 28, 1959	136	38	6
1959–60	October 26, 1959	February 29, 1960	127	36	6
1960–61	October 24, 1960	February 28, 1961	128	36	6
Average			133	37	6

season take. Except for some differences in daily limits, similar regulations applied in most of the major cottontail range of the State.

FINDINGS

During the five hunting seasons covered, 204 individuals provided data relating to 3,286 cottontail hunts. The number of cooperators ranged from 49 in 1956–57 to 102 in 1960–61 (Table 2). Since coop-

Table 2. Summary of Cottontail Hunts Reported by Cooperators

Season	Number of cooperators	Number of hunts			Hunter hours		
		With dogs	Without dogs	Total	With dogs	Without dogs	Total
1956–57...	49	315	144	459	2,471.50	723.50	3,195.00
1957–58...	84	420	145	565	3,258.75	628.00	3,886.75
1958–59...	81	609	160	769	4,619.50	696.75	5,316.25
1959–60...	86	582	163	745	4,357.75	646.50	5,004.25
1960–61...	102	528	220	748	3,374.00	882.50	4,256.50
Total....	402*	2,454	832	3,286	18,081.50	3,577.25	21,658.75

* Actual number of individuals who submitted data was 204.

erators provided data on all members of their hunting parties, the actual number of hunters for which at least some hunting activity was recorded was much larger. In addition to hunts for cottontails only, data relating to almost 200 hunts in which other species were also involved were obtained. Unless otherwise specified, the findings reported here apply to hunts in which cottontails were the only game known to have been pursued. While the representativeness of these cooperators cannot be fully evaluated, available evidence indicates that they had an above-average interest in cottontail hunting.

Dogs were used on nearly three out of four hunts. Since such hunts were generally longer than those in which no dogs were used, the difference in terms of hours afield was even greater. Much of the data has been analyzed on the basis of these two groups. Some of the differences shown may have been due to sample size. However, it is felt that most of the variations reflected existent conditions.

The size of the sample upon which the results are based was relatively small. Nevertheless, the findings provide an interesting insight into the activities of a group of hunters pursuing their sport under relatively liberal regulations. Such information has been reported only infrequently in the past. Furthermore, comparisons of these data with the results of the statewide small game take survey and of the expanded survey of small game hunters made under this project (see Discussion) tend to augment the findings and enhance their meaning.

Number of Hunts per Season

The average number of hunts per cooperator ranged from less than seven in 1957–58 to more than nine in the following year (Table 3). Variations undoubtedly reflected the relative favorability of hunting conditions. Thus, heavy snows and low temperatures in 1957–58 and

TABLE 3. NUMBER OF COTTONTAIL HUNTS PER COOPERATOR AND THEIR DURATION

Season	Average number of hunts per cooperator	Average duration (hours)		
		With dogs	Without dogs	Total
1956–57	9.4	3.5	2.6	3.2
1957–58	6.7	3.3	2.5	3.1
1958–59	9.5	3.4	2.6	3.3
1959–60	8.7	3.3	2.4	3.1
1960–61	7.3	3.1	2.1	2.8
Average	8.2	3.3	2.4	3.1

1960–61 resulted in a noticeable drop in hunter activity compared with that in years of average or mild winters.

Individuals varied considerably in the number of hunts made per season (Figure 2). The majority averaged six or less trips, while 25 per cent hunted cottontails from 6 to 12 times a season. Only five instances (1.2 per cent) of more than 30 hunts per season were recorded. Hunters with dogs generally made more trips than those without dogs; the average for those who used dogs on all their hunts was 8.0 as compared with 4.6 for those who hunted without dogs on all trips. The

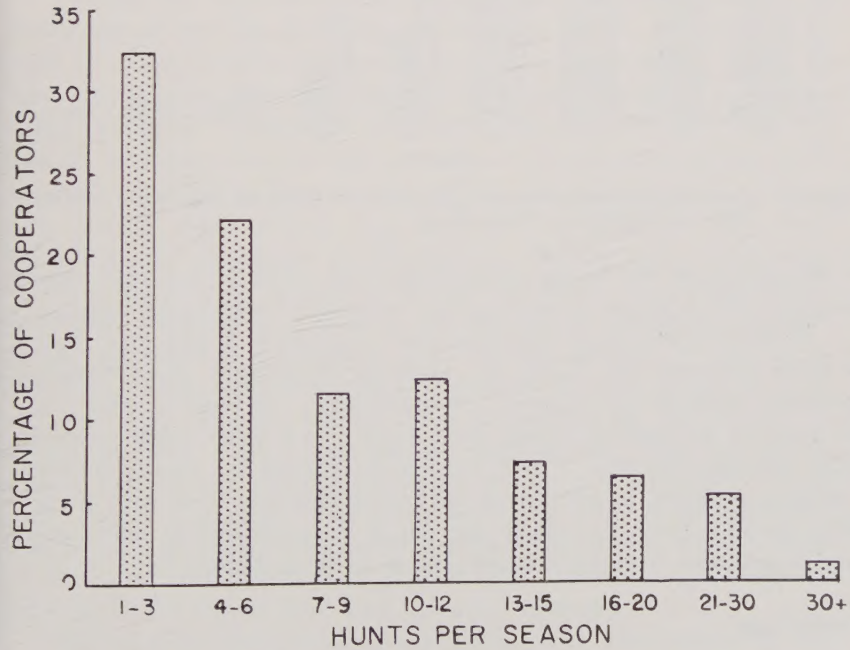

Figure 2. Number of cottontail hunts per season made by cooperators.

difference (3.4 hunts per season) represented almost 75 per cent greater effort for hunters with dogs.

DURATION OF HUNTS

Except for the 1960–61 season, the average number of hours per hunt remained fairly consistent throughout the study (Table 3) and averaged 3.1 hours. The lower figure for 1960–61 likely reflected the unfavorable late-season hunting conditions as well as the relatively high proportion of hunts without dogs in that season's sample. Of the 3,286 hunts reported, the majority (65 per cent) were between 2 and 4 hours in length; 2-hour hunts were the most frequent (Figure 3). Hunts of 1 hour

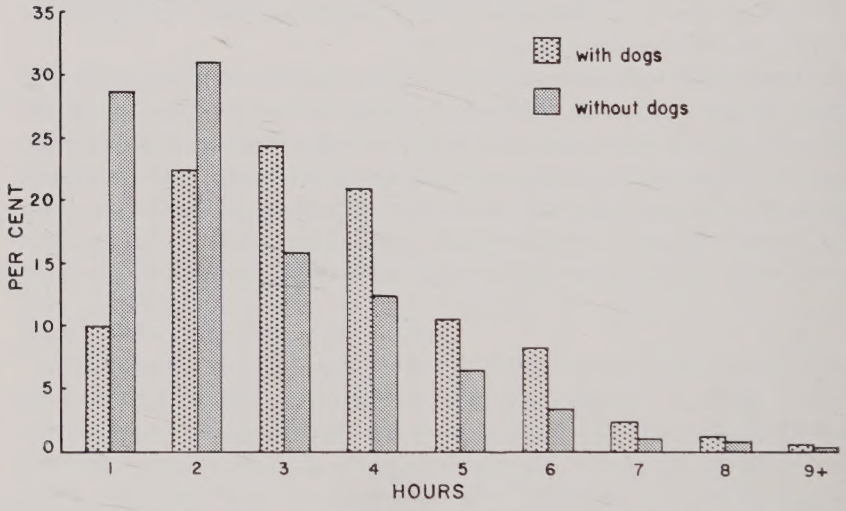

Figure 3. Duration of cottontail hunts (each period includes all fractions of an hour above preceding hour designation).

or less accounted for 15 per cent of the total, while 10 per cent were between 4 and 5 hours. Less than 4 per cent were longer than 6 hours.

Hunts in which dogs were used were consistently longer than those in which they were not (Table 3). Over the five seasons, this difference amounted to 38 per cent or about 1 hour per hunt. In terms of frequency the majority of hunts with dogs lasted from 2 to 4 hours, while most of those without dogs were 1 to 2 hours long (Figure 3). Hunts of over 5 hours constituted 12 per cent of the former and only 5 per cent of the latter group. Some, but likely not all, of these differences may have been due to time required to bring dogs in at the end of the hunt.

PARTY SIZE

The average size of hunting parties was consistent, ranging from

TABLE 4. AVERAGE SIZE OF COTTONTAIL HUNTING PARTIES

Season	With dogs	Without dogs	Total
1956–57	2.1	1.7	2.0
1957–58	2.1	1.6	2.0
1958–59	2.0	1.5	1.9
1959–60	2.1	1.5	2.0
1960–61	1.9	1.7	1.9
Average	2.0	1.6	1.9

1.9 to 2.0 over the five seasons (Table 4). The average size for parties in which dogs were used (2.0) was consistently larger than that for those without dogs (1.6).

NUMBER OF DOGS USED

Dogs were used on nearly 75 per cent of the hunts reported, representing 84 per cent of the hours afield. An average of 1.7 dogs were used per hunt with dogs; this figure was consistent, varying annually from 1.6 to 1.8.

DISTRIBUTION OF HUNTING EFFORT

Perhaps the most interesting information obtained related to the distribution of hunting effort through the open season. This was measured in terms of both number of hunts and hours afield (Table 5). Generally, hunting effort was well distributed throughout the 4½-month season (Figure 4). However, the distribution of effort was somewhat different for hunts with and without dogs. In both groups average hunting effort was high in October and the first half of November. Thereafter, hunting effort without dogs declined to a relatively stable level throughout the remainder of the season. Hunting effort with dogs showed a more erratic pattern; it dropped off sharply in the last half of November, increased to a peak in the last half of December, declined through the first half of February, and increased again in the last half of February. These differences may be explained in terms of general hunting conditions. Hunters without dogs apparently were less detered by severe conditions. Late winter weather, especially the depth and texture of snow, can greatly influence the ability of dogs to move about. Thus, in two seasons of relatively severe snow conditions (1957–58 and 1960–61) hunting effort with dogs dropped off sharply in late winter, while in other seasons it was relatively high in January and February. The majority of hunts (almost 65 per cent) took place on weekends.

The consistent drop in cottontail hunting with dogs during the last two weeks in November coincided with the big game season. Obviously,

TABLE 5. DISTRIBUTION OF COTTONTAIL HUNTING EFFORT BY HALF-MONTH PERIODS

Period *	1956–57		1957–58		1958–59		1959–60		1960–61		Average	
	With dogs	Without dogs	With dogs	Without dogs	With dogs	Without dogs	With dogs	Without dogs	With dogs	Without dogs	With dogs	Without dogs
October §	17.1 19.6	24.3 29.0	22.6 29.8	18.6 21.5	12.3 13.7	11.9 19.1	5.5 5.0	4.3 4.7	16.8 19.3	11.5 17.5	14.0 16.3	13.6 18.5
November 1–15	10.5 14.5	16.0 23.4	14.8 14.5	24.1 23.7	12.6 11.6	10.0 7.1	13.9 15.6	17.2 15.0	19.7 25.0	10.6 13.3	14.5 16.0	15.1 16.3
November 16–30	7.9 8.7	11.1 9.4	6.4 5.7	14.5 16.6	4.9 4.8	8.1 8.0	5.3 6.5	9.8 8.9	12.3 11.7	11.5 13.4	7.2 7.2	11.0 11.3
December 1–15	8.3 5.2	13.9 14.8	13.1 10.8	7.6 5.5	11.2 12.2	16.9 13.8	10.5 11.0	7.4 7.0	7.9 8.9	8.8 6.1	10.3 10.1	10.7 9.4
December 16–31	17.1 14.7	7.6 4.3	19.5 17.3	11.7 11.2	12.5 9.0	13.1 14.8	17.4 15.9	13.5 13.6	17.3 18.0	10.6 11.8	16.5 14.6	11.3 11.1
January 1–15	7.6 6.8	8.3 3.9	12.6 11.3	10.3 13.1	10.7 10.6	7.5 6.1	14.3 13.4	12.3 15.7	10.6 6.7	12.4 6.4	11.5 10.2	10.4 8.7
January 16–31	9.9 8.9	7.6 3.8	5.0 5.0	4.8 4.3	10.2 10.5	14.4 11.8	10.0 9.1	15.3 15.9	5.8 4.4	11.5 7.8	8.3 7.8	11.0 8.6
February 1–14	7.9 7.0	4.9 2.6	4.5 4.9	4.8 2.2	10.8 10.7	5.0 3.3	11.2 9.6	9.2 7.2	2.3 1.2	15.7 17.4	7.7 7.1	8.6 7.1
February 15–28 (29)	13.7 14.6	6.3 8.8	1.4 0.8	3.4 1.9	14.8 16.9	13.1 16.0	11.9 13.9	11.0 12.1	7.3 4.8	7.4 6.2	10.1 10.7	8.3 9.0
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

* For each period, upper figures are percentages of hunts; lower figures are percentages of gun-hours.
§ From opening date (see Table 1) to end of month.

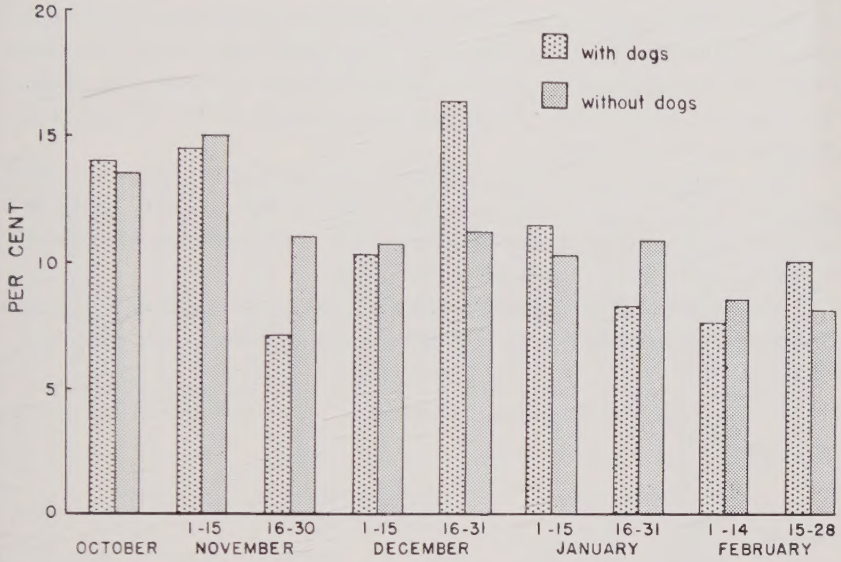

Figure 4. Distribution of cottontail hunts by half-month periods. Data for October represent period beginning on the opening date of season (see Table 1).

many cottontail hunters were reluctant to take their dogs afield during this period.

HUNTING SUCCESS

Cooperators and members of their parties saw over four rabbits per hunt and took nearly two (Table 6). About 43 per cent of the rabbits seen were taken. Average numbers taken per trip were consistent during four seasons. However, this figure was somewhat greater in 1959–60.

TABLE 6. AVERAGE NUMBER OF COTTONTAILS SEEN AND NUMBER TAKEN PER HUNT

Season	With dogs			Without dogs			Total		
	Number seen	Taken		Number seen	Taken		Number seen	Taken	
		Number	Per cent		Number	Per cent		Number	Per cent
1956–57	4.90	1.96	40.0	3.78	1.31	34.5	4.55	1.76	38.6
1957–58	4.51	1.89	41.9	2.83	1.07	37.7	4.08	1.68	41.2
1958–59	4.22	1.67	39.6	4.14	1.69	40.9	4.21	1.68	39.9
1959–60	4.52	2.50	48.8	2.75	1.24	45.1	4.13	1.99	48.3
1960–61	3.62	1.74	48.3	3.94	1.45	36.9	3.71	1.66	44.7
Average	4.30	1.89	43.9	3.53	1.37	38.7	4.10	1.76	42.8

Despite the difference in sample size, the average take per hunt was about as consistent for hunts without dogs as for those with dogs, but the increase in 1959–60 was due exclusively to a greater success in hunts with dogs. The season of highest take for hunts without dogs (1958–59) was the lowest for hunts with dogs.

On a per-hunt basis, parties with dogs consistently saw more rabbits (about 40 per cent) and were more successful in the numbers taken as well as in the percentage taken of those seen.[3] This apparent advantage of dogs was not reflected on a gun-hour basis.

Hunters required about 1½ hours afield to see a rabbit and almost 4 hours to take one (Table 7). In three seasons, differences in numbers

TABLE 7. AVERAGE NUMBER OF COTTONTAILS SEEN AND NUMBER TAKEN PER GUN-HOUR

Season	With dogs		Without dogs		Total	
	Seen	Taken	Seen	Taken	Seen	Taken
1956–57....	0.64	0.26	0.75	0.26	0.67	0.26
1957–58....	0.58	0.24	0.65	0.25	0.59	0.24
1958–59....	0.56	0.22	0.95	0.39	0.61	0.24
1959–60....	0.60	0.29	0.69	0.31	0.62	0.30
1960–61....	0.57	0.27	0.98	0.36	0.65	0.29
Average....	0.58	0.26	0.82	0.32	0.62	0.27

taken per gun-hour on hunts with and without dogs were negligible. In two years, however, hunters without dogs were decidedly more effective, the difference amounting to over 80 per cent in 1958–59. Thus, while the use of dogs resulted in a higher proportion of the rabbits seen being taken, it was of no advantage in increasing take per unit of effort.

In addition to annual variation in success, differences within seasons were determined (Figure 5). On hunts with dogs, the number of rabbits seen and taken per gun-hour remained remarkably consistent throughout the 4½-month season. However, on hunts without dogs success was higher in the latter part of the season.

The average numbers of rabbits seen and taken per hunter was relatively constant (Table 8). In each season, individual hunters saw

[3] The 1960–61 season was an exception, equal numbers being reported seen on hunts with and without dogs. This may have been the result of misunderstanding with respect to the change in the reporting system; in that year hunters were requested to record numbers "started" by dogs as well as those actually seen. It is believed that this change likely resulted in an abnormally low figure for numbers reported seen during hunts with dogs. The average number "started" (which was to include both those seen by hunters and those flushed by dogs but not seen) was over five rabbits per hunt.

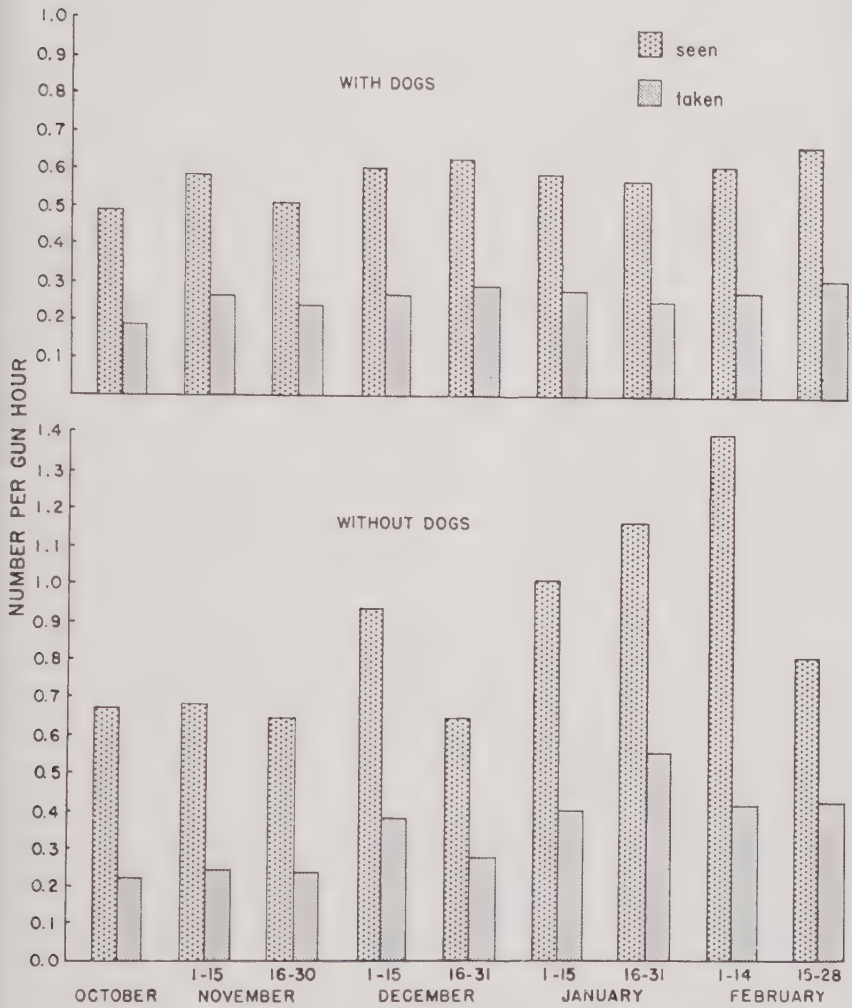

Figure 5. Number of cottontails seen and number taken per gun hour by half-month periods. Data for October represent period beginning on the opening date of season (see Table 1).

from 14 to 22 rabbits and took from six to nine; the averages were 17.5 seen and 7.5 taken.

DISCUSSION

During the five years of this study the "average" volunteer cooperator made about eight hunts for cottontails annually throughout the 4½-month season, mostly on weekends. Each hunt lasted about 3¼ hours during which time he and one companion saw four cottontails and took two, requiring approximately 4 man-hours for each rabbit bagged. When hunting with dogs (one or two on the average) his hunts were longer,

Table 8. Average Success of Individual Cottontail Hunters

Season	Rabbits per hunt		Rabbits per season	
	Seen	Taken	Seen	Taken
1956–57	2.32	0.89	21.8	8.4
1957–58	2.09	0.86	14.0	5.8
1958–59	2.19	0.87	20.8	8.3
1959–60	2.12	1.02	18.4	8.9
1960–61	2.00	0.89	14.6	6.5
Average	2.13	0.91	17.5	7.5

and he saw and took more rabbits. On an hourly basis, however, his take was at least as high without dogs. He and his companions took a total of 15 rabbits a season. Their success in the late winter months (January and February) was at least as high as earlier in the season.

The findings reported here were derived from a relatively small proportion of the small game hunters within the three-county area. How the characteristics of this group relate to those of the over-all hunter population may only be surmised. In order to appraise the representativeness of this sample better, an expanded survey of small game hunters was undertaken in the 1960–61 season. Over 1,000 names were randomly selected from stubs of small game licenses sold in the three-county area during the previous year. Each individual was requested to maintain and submit monthly records of his cottontail hunting activities in those counties in exactly the same manner as those provided by the volunteer cooperators. A total of 274 hunters furnished usable data on 1,417 cottontail hunts.

During the 1960-61 season, the randomly selected hunters averaged 5.2 trips per season and bagged 0.20 rabbits per gun-hour as compared with 7.3 and 0.29, respectively, for the volunteer cooperators (Table 9). This information strongly suggests that, as a group, the volunteer cooperators had a higher-than-average interest in cottontail hunting and were more successful.

Table 9. Comparative Success of Random Sample Respondents and Volunteer Cooperators in 1960–61 Season

Item	Random sample	Volunteer cooperators	Difference (per cent)
Number of hunts	5.2	7.3	+40.4
Rabbits seen per gun-hour	0.45	0.65	+44.4
Rabbits taken per gun-hour	0.20	0.29	+45.0

While this study was in progress a statewide small game take survey[4] was also conducted each year. The results of the latter survey indicate that interest and success in cottontail hunting were higher in the three-county area than in the State as a whole. To some extent, then, the findings for the volunteer cooperators may provide an index to maximum utilization of available cottontail hunting opportunity.

In relation to hunting regulations, the results of this study indicate that the existing daily bag limit of six did not restrict the take to any measurable degree. Although tabulations were not made, it is believed unlikely that more than 40 party bag limits were filled in the 3,286 hunts reported. All available evidence indicates that cottontail populations were below peak levels during the study.

In some respects the use of potential hunting time by cooperators was low. The average of eight cottontail hunts per season represented less than 10 per cent of the 133 days available for hunting. Since most hunting was done on weekends a more realistic appraisal would be in terms of the 38 weekend days during the open season. On that basis, potential hunting opportunity was more fully used. Figures relating to number of hunts are minimal; data from hunts in which other species were also involved were excluded.

Perhaps of more interest to current regulations was the seasonal distribution of hunting effort. The cottontail season extended from about mid-October through February. In fact, in January and February cottontails and varying hare (in Columbia and Rensselaer Counties) were the only small game species that could be legally hunted in the three-county area. The findings indicate that cooperators took full advantage of this late-season hunting opportunity. Over 37 per cent of the cottontail hunts reported took place in the last two months of the season. This included two seasons of severe late-winter cold and snow conditions. In the three milder winters approximately 44 per cent of the hunts were made in January and February. The seasonal distribution of cottontail hunting effort in other parts of the State is not known. However, there is no evidence to suggest that it differs substantially from that reflected in this study.

A full appraisal of the adequacy of harvesting regulations would entail a measure of the effect of resultant hunting pressure on the species involved. Specific documentation in regard to rabbit populations in the three-county area, and the State as a whole, is beyond the scope of this paper. However, population studies in the three-county area, as well as available information relating to conditions elsewhere in the State, indicate that the harvesting regulations of recent years have had no adverse effect on cottontail abundance.

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[4] See various job completion reports for Federal Aid in Fish and Wildlife Restoration Project W-90-R.

The over-all objective of hunting regulations should be to provide maximum recreational opportunity within biologically safe limitations. The results of this study suggest that this objective comes close to realization under present harvesting regulations for cottontails in New York.

ECOLOGY AND MANAGEMENT OF LARGEMOUTH BASS AND GOLDEN SHINERS IN FARM PONDS IN NEW YORK[1]

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ABSTRACT

Experiments with largemouth bass and golden shiners were conducted in farm ponds in central New York, and the results were compared with those from experiments with largemouth bass and bluegills. Natural mortality of originally stocked bass was somewhat lower in bass-shiner ponds than in bass-bluegill ponds. Growth rates of bass were somewhat higher in bass-shiner ponds. Bass reproduction was more regular in the bass-shiner ponds. Therefore, standing crops of bass tended to be considerably higher in bass-shiner ponds, permitting larger harvests. In spite of satisfactory initial reproduction and suitable spawning sites, shiner populations began to decline 2 years after stocking and disappeared in some ponds, presumably due to predation. Standing crops of bass increased and bass reproduction continued, in spite of decreasing shiner populations.

Stocking with the bass-shiner combination should be encouraged on a trial basis in New York ponds. This combination may be more advantageous than bass and bluegills for the pond owner who is not particularly interested in bluegills and whose pond is quite small and fairly shallow with a surface temperature that rises above about 73° F. in summer.

This paper is the second of a three-part study (see Regier, 1963a, 1963b) the over-all objective of which was to construct a factual and reasoned basis for a fish-stocking and management policy applicable to warm-water farm ponds in New York. It concerns experiments with largemouth bass (*Micropterus salmoides*) and golden shiners (*Notemigonus crysoleucas*). The first paper (Regier, 1963a) included a general account of the problem and the studies undertaken. It also described the methods used that were common to all three phases of the investigation. A more detailed discussion of the objectives and methods pertaining to the work on bass and shiners[3] is given here.

Before 1958, warm-water farm ponds in New York were stocked almost exclusively with largemouth bass and bluegills (*Lepomis macrochirus*), at least when stocked with fish provided by government agencies. Since 1958, largemouth bass and golden shiners have been stocked in some ponds on recommendations based on preliminary findings of this project.

A number of biologists have commented on the suitability of the golden shiner as forage for piscivores such as the largemouth bass. Davis and Wiebe (1930), referring to use of golden shiners in Iowa bass-rearing ponds, stated:

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[1] Derived from a Ph.D. thesis submitted to the Graduate School at Cornell University in 1961. This study is a contribution of Federal Aid in Fish and Wildlife Restoration Project F-17-R. Personal acknowledgements are made elsewhere (Regier, 1963a).

[2] Present affiliation: Southern Research Station, Department of Lands and Forests, Maple, Ontario.

[3] As used in this study, "bass" refers to largemouth bass and "shiner" refers to golden shiner.

> "It is doubtful if there is any other species which combines in an equal degree the desirable qualities of an all-around forage fish. The golden shiner has a very wide geographical distribution and is abundant in suitable habitats throughout its range. It is by nature a fish of quiet and stagnant waters and consequently is perfectly at home in the ordinary fish pond. The young feed chiefly on microscopic crustacea and plankton algae. As they grow older vegetable material, consisting of algae, forms a larger percentage of their food, although even adults may feed on crustacea and insects to a considerable extent."

In Michigan, Ball (1952) found that:

> "Combinations of largemouth bass and golden shiners . . . have been found satisfactory in weedy ponds here. Where the primary interest of the pond owner is sport fishing and large fish are preferred, this combination is superior to the bass-bluegill combination in that bass reach a catchable size in a shorter time . . . It appears that adequate brood stocks escape predation and young golden shiners are produced at rates which allow bass to continue to make good growth."

Forney (1957) began experiments in New York during 1953 in rearing golden shiners and other species as bait fish in farm ponds. His findings included the following. Golden shiners began to spawn in late May and continued to spawn through the summer. Yearling shiners over 2.5 inches long were usually mature. Shiners failed to reproduce in three ponds having low water transparency as well as an absence of filamentous algae and higher aquatic plants on which shiners could deposit eggs. The number of golden shiners produced from an original stocking the year before was governed more by the physical and biological environments than by the stocking rate, over the range of 200 to 1,880 adults per acre.

Forney's preliminary findings from his bait pond experiments, and the findings of Davis and Wiebe, Ball, and others, indicated that largemouth bass and golden shiners were a promising combination for New York ponds whose owners were not interested in bluegills. Therefore, experiments with bass and shiners were begun under this project in 1954.

MATERIALS AND METHODS

The materials and methods that pertained especially to the work on bass and shiners are described under the following topics.

Experimental Bass-Shiner Categories

Project personnel stocked eight ponds with bass and shiners and collected data from two more stocked by U. S. Soil Conservation Service technicians. Two of the 10 ponds were stocked in 1954, the remaining eight later. The first two ponds received stock available at the time, which consisted of a variety of age I+ and II+ bass and I+ and II+ shiners. The other eight received about 100 age 0+ bass and about 400 age I+ and II+ shiners per acre stocked during the same year in each case. This stocking rate was chosen on the basis of Forney's results with golden shiners in bait ponds. For purposes of this paper, the bass-shiner ponds are divided into two categories: those stocked in 1954 are called "non-standard"; and those stocked later are called "standard".

One of the two non-standard ponds yielded few data for reasons given in the next section; hence, this category was actually represented by only one pond. Emphasis in this paper thus centers on the standard bass-shiner category and only short references are made to findings in the non-standard category.

Experimental Ponds

General characteristics of project ponds were given by Regier (1963a). Table 1 contains more detailed information on the bass-shiner ponds.

Table 1. Characteristics of Project Ponds Stocked with Bass and Shiners

Pond	Mean area (acres)	Age of pond at stocking (years)	Period studied	Footnote remarks
Non-standard				
Earl	0.25	2	1954–1957	a, f
Myers	0.21	3	1954–1960	
Standard				
Hatchery C	0.16	1	1955–1960	b
Hatchery D	0.16	1	1955–1961	b
Hatchery E	0.20	1	1955–1961	b
L. Hayes	0.40	0+	1957–1961	
Marshall	0.50	>3	1955–1956	c, f
Newhart	1.00	1	1957–1961	d, f
Smith	0.25	>2	1955–1961	e
Swanson	0.52	6	1955–1961	

a Pond leaked badly and almost dried out in 1956 and 1957, experiment discontinued.
b These ponds fed from stream, others by run-off water entirely.
c Fish suffered severe winterkill, experiment discontinued and no data available.
d Impossible to control weeds sufficiently to permit inventories after 1958.
e Pond surface area fluctuated quite markedly in 1959 and 1960, apparently due to moderately severe leaking.
f Estimates of mean area for these ponds based on surveys by SCS technicians, those for all other ponds based on surveys by the author.

The range and distribution in surface area of the standard ponds were similar to those for each bass-bluegill category (cf. Table 2 in Regier, 1963a). Relative fertility data are given under a subsequent topic (see Table 8).

Stocking Data

The stock for bass-shiner experiments begun in different years came

Table 2. Stocking Record for Bass and Shiners in Project Ponds*

Experimental category	Pond	Source of stock	Number per acre	Mean total length (inches)	Date stocked
		Bass			
Non-standard..	Earl	Unknown	40	§	Oct. 1954
	Myers	Cornell Hatchery	170	3.5†	April 1954
Standard.....	Hatchery C	Baldwin pond	95	2.5	Oct. 1955
	Hatchery D	Baldwin pond	95	2.5	Oct. 1955
	Hatchery E	Baldwin pond	100	2.5	Oct. 1955
	Marshall	Baldwin pond	100	2.5	Oct. 1955
	Smith	Baldwin pond	80	2.5	Oct. 1955
	Swanson	Baldwin pond	95	2.5	Oct. 1955
	Newhart	U. S. Fish & Wildl. Ser.	100	2±	Aug. 1956
	L. Hayes	U. S. Fish & Wildl. Ser.	105	2±	Aug. 1957
		Shiners			
Non-standard..	Earl	Unknown	1,000	3.5	Oct. 1954
	Myers‡	Cornell Hatchery	240	>2.5	April 1954
		Robin pond	530	3.5	Sept. 1957
Standard.....	Hatchery C	Cornell Hatchery	380	>2.5	Oct. 1955
	Hatchery D	Cornell Hatchery	380	>2.5	Oct. 1955
	Hatchery E	Cornell Hatchery	500°	?	Oct. 1955
	Marshall	Cornell Hatchery	240	?	Oct. 1955
	Smith	Cornell Hatchery	320	?	Oct. 1955
	Swanson	Cornell Hatchery	380	?	Oct. 1955
	Newhart	Bait dealer	400	?	Aug. 1956
	L. Hayes	Bait dealer	400	?	Aug. 1957

* All bass were young of the year unless otherwise noted; all shiners were adults. i.e., age I+ or older.
§ Apparently stunted 2-year-olds.
† Stunted yearlings.
‡ Restocked after first shiner population disappeared.
° Plus unknown number of age 0+ shiners.

from different sources, and the fish were presumably different genetically. Sources of stock and other data on stocking are summarized in Table 2.

Except for the non-standard ponds (Earl and Myers), stocking rates were to have been 100 fingerling bass and 400 adult shiners per acre; for reasons unknown to the author exceptions occurred for shiners in the Hatchery E and Marshall ponds. Except in these two cases, the actual stocking rates in the standard bass-shiner ponds approximated closely the planned 100–400 ratio, the greatest aberration (minus 20 per cent) occurring in Smith pond.

Project personnel took pains to ensure that bass and shiners entered the ponds in good condition. Presumably this was also the case in the two ponds (L. Hayes and Newhart) stocked by SCS technicians. How-

ever, it was reported that a severe mortality of shiners, 40 per cent or higher, occurred shortly after stocking the L. Hayes pond.

Data Collection

Data were recorded on: population size, growth, reproduction, standing crops, and harvests of bass; relative abundance or population size and reproduction of shiners: pond fertilization, weed control and other management methods.

In 1958, methods used to estimate population size in bass-bluegill ponds were altered considerably (Regier, 1963a). Similar changes were made in methods of inventorying bass populations in bass-shiner ponds, and these more reliable methods were used until experiments were terminated in 1961.

Harvestable size for bass was taken to be 9 inches total length in 1955, and 10 inches thereafter (as in the bass-bluegill ponds). Some of the within-strata estimates for bass-bluegill ponds had to be adjusted to make the data comparable for all years of the experiments. No adjustments were necessary for bass-shiner estimates since no bass between 9 and 10 inches long were found in the ponds (i.e., Earl and Myers ponds) at the time of the 1955 inventories.

Before 1958, only the relative abundance of adult and young-of-the-year shiners at the time of inventory was noted. During and after 1958 it was possible to make some estimates of the population size for shiners by methods similar to those used for bass.

Methods of making reproduction checks and of collecting management data have been described and discussed adequately by Regier (1963a).

RESULTS

Findings of the study, in terms of survival, growth, reproduction and yield, are given under separate topics. Pond-owner reactions are also summarized.

Survival of Original Stock

Experiments with bass and shiners were designed to provide information on the following questions concerning survival. What are typical survival rates for bass in unfished bass-shiner ponds? How do bass survival rates in bass-shiner and bass-bluegill populations compare? How long do shiners survive in the ponds?

Survival of Bass Stock Data available on survival rates of bass in the absence of fishing, and methods used to standardize these data to permit comparisons, were similar to those described by Regier (1963a). Figure 1 contains summaries and a comparison of the data on survival of the original bass stock in bass-bluegill and bass-shiner ponds. All

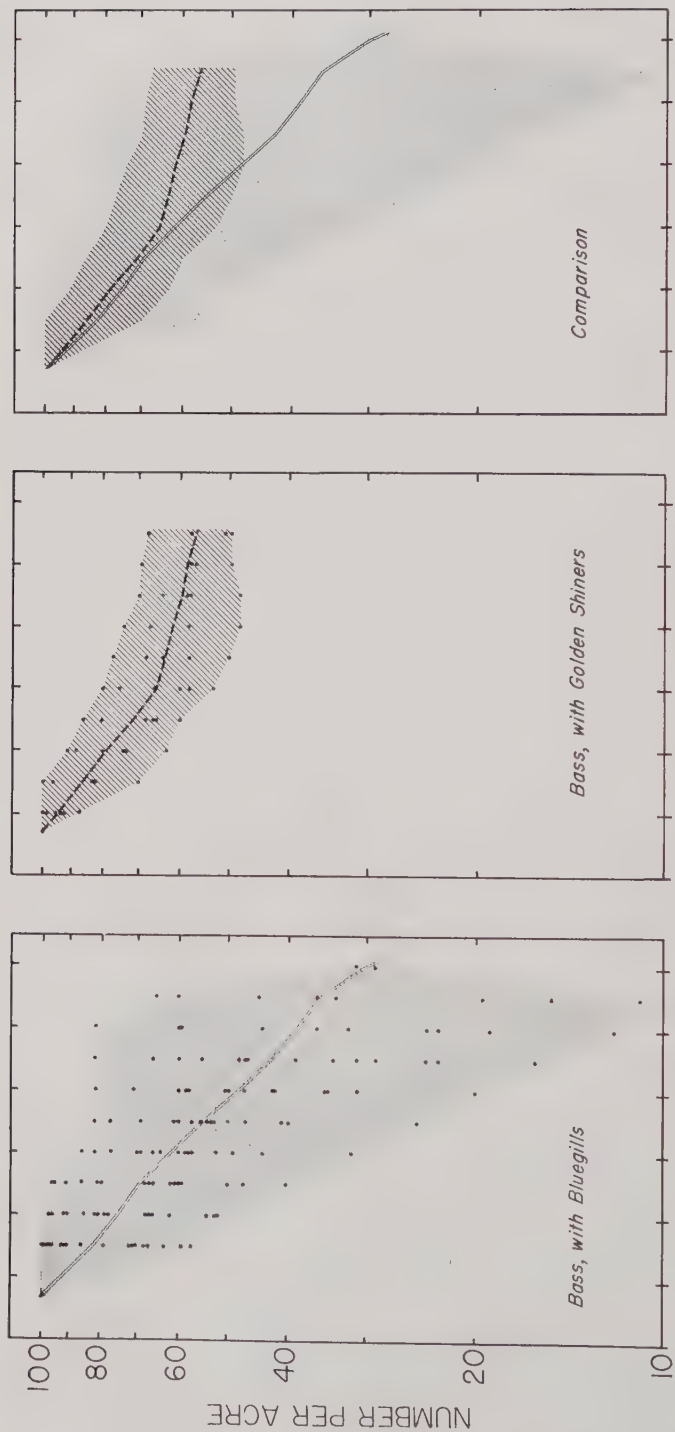

Figure 1. Summary and comparison of survival, in the absence of fishing, for the original bass stock in combination with bluegills and in combination with shiners.

the data on survival of bass in the three bass-bluegill categories were lumped since no significant differences between categories were found (Regier, 1963a). The data on bass survival in bass-shiner ponds were those from the standard category. "Survival rate" means the estimated rate of survival in the absence of fishing unless otherwise specified.

Survival data were adjusted as in Regier (1963a, Figure 4). Mean survival rates for bass stock in bass-shiner ponds were estimated to be about 83 per cent per year for the first 2.3 years and about 94 per cent per year for the next 2.7 years. Corresponding estimates for bass in bass-bluegill ponds were about 80 per cent per year for about the first five years.

Estimated bass survival rates in the non-standard bass-shiner ponds were as follows. All bass in the Earl pond, stocked with 40 age II+ fish per acre, survived the first year, and about 60 per cent per year survived during the next two years; during this time the pond surface area fluctuated markedly. The Myers pond was stocked with 170 age I+ bass per acre; about 85 per cent per year survived for the first 3-year period and about 50 per cent per year for the next two years. Some of the mortality in the last two years in the Myers pond may have been due to unreported harvests.

Differences between estimates of mean survival of bass in the bass-bluegill and standard bass-shiner ponds were clearly non-significant for the first three years; were differences significant thereafter? Wilcoxon's two-sample non-parametric test (Steel and Torrie, 1960) was used to test the hypothesis that differences between the bass-bluegill and standard bass-shiner ponds, with respect to bass survival 3 to 5 years after stocking, were non-significant. Data used for the tests were the estimated number of survivors per acre adjusted to remove the effect of fishing. The test indicated significantly greater bass survival in the bass-shiner ponds at 4 and 4½ years after stocking.

Concerning bass-shiner and bass-bluegill ponds in general this evidence should be considered only suggestive since project ponds were not assigned to categories strictly at random. If, however, it should prove generally valid, the reasons are unknown.

None of the bass populations in bass-shiner ponds was fished excessively (see section on harvests). One or more individuals of the original stock survived in all ponds until experiments were terminated, except in the Smith pond where the last original bass was removed at age V+ in 1960. Some VI+ bass were captured in the Hatchery D and Hatchery E ponds in 1961.

Survival of Shiner Stock Only data on relative abundance of adult and young-of-the-year shiners were recorded before 1958. Also, no records were kept on the size of shiners stocked. Thus the data on the original shiner stock do not provide detailed estimates of survival

rates. However, from the data on relative abundance before 1958, and from length-frequency distributions taken in 1958 and thereafter, it is possible to infer approximately how long some original shiner stock survived in the ponds. The results are as follows.

Some of the original shiner stock was present 2 years after stocking in nine bass-shiner ponds; in two of the nine ponds some survived until 3 years after stocking. (In the tenth pond all bass and shiners died the first winter after stocking.) Apparently very few or none of the originally stocked shiners survived beyond the third summer. Assuming that the youngest shiners stocked were yearlings, the data indicate that some original stock attained ages of III+ and IV+ in farm ponds that had been stocked with bass also.

No serious mortalities of shiners shortly after stocking were observed or reported except in the L. Hayes pond where 40 per cent or more of the original stock died soon after stocking. However, some mortality was observed after most inventories. Mesh sizes were $\frac{5}{8}$ inch and $\frac{3}{4}$ inch for the larger seines used. Larger shiners were frequently gilled or wedged in these seines. Though they were removed as carefully as practical some were severely injured and died as a result. However, no case of severe mortality was observed following inventory. Bass mortality resulting from inventories was either light or nonexistent in these ponds.

Growth Rates

Data on growth of the original bass stock in the bass-shiner ponds were summarized and compared with corresponding data from standard bass-bluegill ponds.[4] Growth rates of identifiable selected year classes of bass hatched in the ponds were then examined. Finally, available data on shiner growth were examined and compared with growth of shiners in bait ponds in New York.

Methods of summarizing growth data were similar to those used for bass-bluegill data by Regier (1963a). In general the data for bass from bass-shiner ponds were more reliable than those from bass-bluegill ponds, largely because experiments in them were begun later and project personnel were able to benefit from experience with bass-bluegill inventories.

Growth of Stocked Bass Figure 2 shows the weights attained by bass in standard bass-shiner ponds at times of inventory during the years following stocking. Each point is a population mean; category means are also given and connected with lines. Similar data are given for the standard bass-bluegill ponds. Category means are then plotted separately to permit visual comparison.

[4] Standard bass-bluegill ponds were those stocked with 100 bass fingerlings and 1,000 bluegill fingerlings per acre, simultaneously.

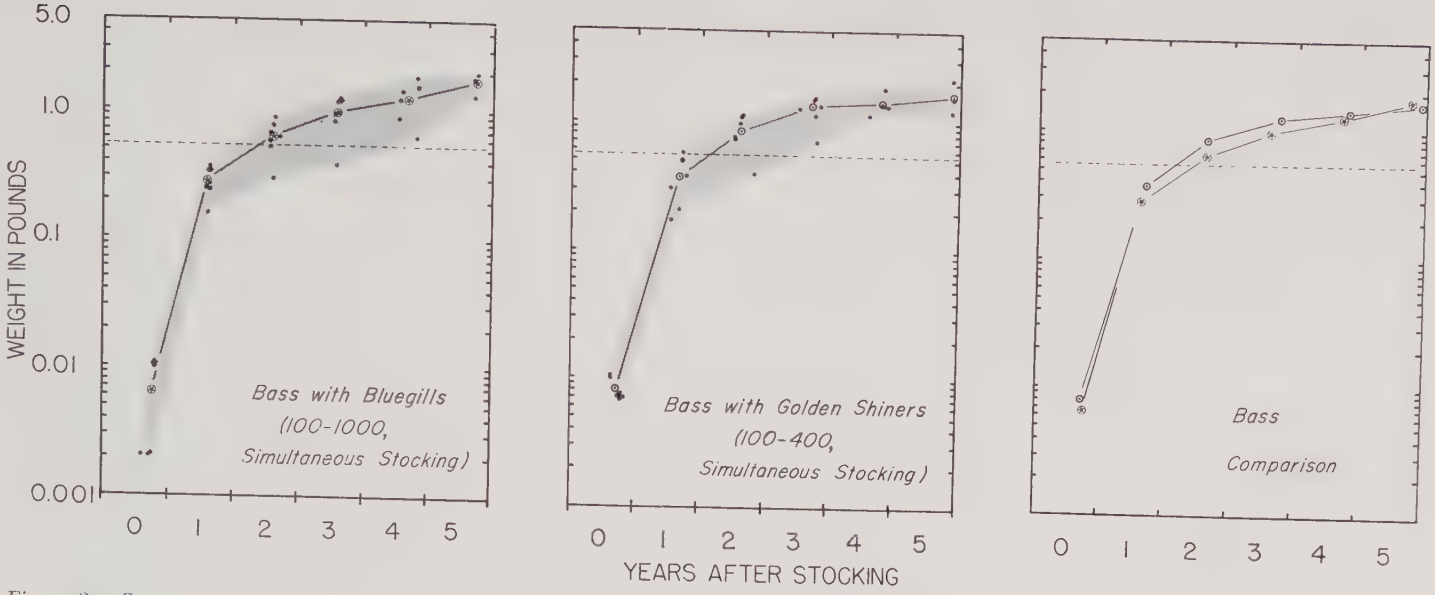

Figure 2. Summary and comparison of growth for the original bass stock in combination with bluegills and in combination with shiners.

The comparison in Figure 2 indicates that, on the average, bass of a given age were larger in the standard bass-shiner ponds than in the standard bass-bluegill ponds. However, the differences were not pronounced considering within-category variation. The evidence suggests that bass growth may, in general, be somewhat more rapid in standard bass-shiner than in standard bass-bluegill ponds.

Bass in standard bass-shiner ponds generally attained harvestable size earlier than those in bass-bluegill ponds. Among the former, most bass in one pond attained harvestable size within 1 year after stocking while this required almost 3 years in another (L. Hayes pond). Comparable data were 2 and 4 years, respectively, for the bass-bluegill ponds. The poor growth in the L. Hayes pond might be attributed in part to its low fertility. This pond appeared to be the least fertile of all project ponds judging from the rate of accumulation of bottom muck and the high transparency of the water. It apparently received no direct fertilization and little nutrient material in runoff.

A brief summary of growth data from the two non-standard bass-shiner ponds follows. The Myers pond was stocked in the early spring of 1954 with small yearlings which attained a mean size of 0.8 pound at midsummer in 1955 and 1.0 pound a year later. The 1.0-pound mean weight was maintained for the following three years. Failure to grow during the latter three years may have been due to low harvests coupled with high total standing crops of bass (120 to 150 pounds per acre) and an absence of shiners. In the Earl pond, bass, originally stocked as age II+ fish, attained a weight of 1.0 pound at midsummer a year following stocking and 1.3 pounds 2 years later. The surface area fluctuated markedly in this pond.

Growth of Bass Spawned in Ponds Table 3 shows the size attained at the end of successive growing seasons, except the first, by the first year class of bass spawned in six bass-shiner ponds. Hatchery E pond had a small first year class and an abundance of shiners; most of the bass attained harvestable size at age I+, i.e., at the end of their second growing season. Hatchery C pond had a small year class and relatively few shiners; most of the bass reached 10 inches at age II+, i.e., at the end of their third growing season. Smith, Swanson, Hatchery D and Myers pond had moderately large or large first year classes of bass most of which failed to attain harvestable size as 3-year-olds. Myers pond had a large year class and few or no shiners; most of the bass failed to reach 10 inches at age IV+.

In the standard bass-shiner ponds for which data are available, some bass in the first year class attained 10 inches at age II+ and in one pond at I+. Bass of the first year class in bass-bluegill ponds required about a year longer (cf. Table 6 in Regier, 1963a). The more rapid bass growth observed in bass-shiner ponds may have been due either to less food com-

TABLE 3. GROWTH OF FIRST YEAR CLASSES OF BASS SPAWNED IN BASS-SHINER PONDS

Pond	Relative size of year class	Mean weight at end of growing season			
		Second	Third	Fourth	Fifth
Non-standard					
Myers	large	0.14	0.24	0.40*	0.47*
Standard					
Smith	large	0.11	0.27*	0.25*	. .
Swanson	large	0.12	0.30*	0.44*	. .
Hatchery D†	moderate	0.22	0.43*	0.37*	. . .
Hatchery C	small	0.25	0.70*	0.85§	. . .
Hatchery E‡	small	0.66*	....	....	. . .

* Some members of year class had attained harvestable size, i.e., 10 inches in length of about 0.55 pound.
§ All members had attained harvestable size.
† The decrease in mean weight from the third to fourth seasons was due, at least in part, to selective harvests having been made of the larger fish in the year class.
‡ Bass first spawned in this pond during 1959; consequently data were available for only the first season in this case.

petition between bass and shiners than between bass and bluegills, or to greater bass predation on shiners than on bluegills, or to both.

Members of large first year classes of bass in bass-shiner ponds varied considerably in size. Two examples follow. At age I+ in the Swanson pond the largest and smallest bass in the year class were about 9.5 inches (0.42 pound) and about 5.0 inches (0.05 pound), respectively. At I+ in the Smith pond the range was from 9.9 inches (0.47 pound) to about 4.0 inches (0.03 pound). According to Lawrence (1958) a 9.5-inch largemouth bass can swallow a 5.2-inch largemouth bass. Thus the largest bass in each of these ponds could have preyed on the smallest bass in its own year class. The length-frequency distributions in a number of cases indicated that this may have happened; the distribution was skewed in the direction of the larger size and appeared truncated in the direction of the smaller. Such asymmetric length-frequency distributions were also noted in large year classes of bass in bass-bluegill ponds.

GROWTH OF STOCKED SHINERS Since shiners were stocked to serve only as prey for the bass, it was decided at the outset of the investigation not to collect data on growth (and survival). However, it became obvious in 1958 that some shiner populations were diminishing and that little extra work was involved in collecting more detailed data on these smaller populations. Some data on growth rates and maximum size attained by shiners are consequently available for the years after 1957.

Quite large shiners were observed in three ponds during the period 1957 to 1960. The ponds and the longest shiner (total length in inches) observed in each were: Newhart, 8.2; Smith, 7.4; and Swanson, 7.1. Probably only the shiners in the Swanson pond were original stock. Lawrence (1958) found that a 16-inch largemouth bass can swallow an 8-inch golden shiner, and a 14-inch bass can swallow a 7-inch shiner. Since the bass-shiner ponds generally contained some 14-inch bass within 3 years after stocking, it is apparent that either all or almost all the shiners were vulnerable to predation.

Length-frequency distributions of shiners are available from four ponds in 1958 and from two ponds each in 1959 and 1960. Mean lengths attained at the end of the first growing season varied from 1.5 to 2.3 inches, and at the end of the second growing season the means ranged from 3.2 to 5.0 inches. It was found impossible to distinguish age II+ from older fish on the basis of length frequencies and scale samples had not been taken; consequently information on the growth of older shiners was not obtained.

Forney (1957) described the growth of golden shiners in bait ponds fairly typical of New York farm ponds. He found the range of within-population means to be 1.7 to 2.9 inches at the end of the first growing season. By late summer of the second growing season the range was 2.4 to 3.6 inches.

Size attained at the end of the first season averaged somewhat lower in the bass-shiner ponds compared with that in the bait ponds discussed by Forney, but it averaged higher at the end of the second growing season. The apparently better growth during the first year in the bait ponds may have been due to supplementary feeding. Better growth during the second year in the bass-shiner ponds may have been due to less intra-specific competition there as a result of a lower density of shiners in relation to the food supply.

Reproduction

Collection of data on reproductive success and the methods used to summarize the data have been discussed by Regier (1963a). Criteria were defined by which reproductive success of bass and bluegills was judged to be zero (Class 0), light (Class 1), moderate (Class 2), or heavy (Class 3). Criteria used for judging reproductive success of shiners were identical with those for bluegills.

This section contains summaries of data on reproductive success of bass and shiners, and a comparison of bass reproductive success in the standard bass-shiner and standard bass-bluegill ponds. Evidence is then presented to indicate that bass reproduction in a pond did not necessarily cease when the forage species (shiner) disappeared.

REPRODUCTIVE SUCCESS OF BASS Table 4 contains data on bass reproductive success in the bass-shiner ponds. Bass stocked at age 0+ in these ponds, as in bass-bluegill ponds, failed to reproduce at I+, but

TABLE 4. SUMMARY OF DATA ON REPRODUCTIVE SUCCESS OF BASS AND SHINERS IN POND POPULATIONS OF TWO EXPERIMENTAL CATEGORIES

Pond	Year stocked	Years after stocking *					
		1	2	3	4	5	6
Non-standard							
Myers	1954	2–3	1–2	0–§	2–§	1–§	2–§
Earl	1954	3–2	0–3	0–3	...	...	...
Standard							
Hatchery C	1955	0–3	3–2	1–1	2–1	2–§	...
Hatchery D	1955	0–2	2–3	2–2	2–1	2–§	⩾1–§
Hatchery E	1955	0–3	0–3	0–2	2–1	3–1	⩾1–§
Smith	1955	0–3	2–3	1–1	3–2	1–0	...
Swanson	1955	0–3	3–2	1–1	2–1	2–0	⩾1–§
Newhart	1956	0–3	2–2	1–1	2–1	...	...
L. Hayes	1957	0–1	2–1	1–0	...	...	...
Mean		0–2.6	2.0–2.3	1.0–1.1	2.2–1.2	2.0–0.2	...

* Numbers under each year correspond to classes of reproductive success described in text; and for each pond the first figure represents bass, the second shiners.
§ No shiners of any age found in pond.

in six of seven ponds they reproduced successfully at II+. The one exception was the Hatchery E pond in which bass apparently failed to reproduce successfully until 4 years after stocking.

The reason for the failure of bass to spawn successfully in the Hatchery E pond at ages II+ and III+ may have been the high population of shiners during the first three years after stocking (see section on standing crops). Nell, Suits and Thomas (1936) reported that golden shiners harrassed spawning bass and apparently prevented successful spawning. The present author also observed shiners harrassing spawning bass.

Data summarized in Table 5 permit a comparison of bass reproductive success in the standard bass-shiner and standard bass-bluegill populations. The evidence indicates that bass in project ponds experienced greater reproductive success when associated with shiners than with bluegills. The probability that all four means for the bass-shiner populations would have been greater than those for the bass-bluegill populations simply by chance is $(\frac{1}{2})^4$ or about 6 per cent. Thus the evidence suggests that bass reproduce more successfully in bass-shiner than in bass-bluegill populations.

TABLE 5. COMPARISON OF REPRODUCTIVE SUCCESS OF BASS IN STANDARD BASS-SHINER AND STANDARD BASS-BLUEGILL CATEGORIES

Category	Years after stocking *					
	1	2	3	4	5	6
Bass-shiner	0	2.0	1.0	2.2	2.0	. .
Bass-bluegill	0	1.0	0.8	1.0	1.1	1.2

* Data are category means.

Once the bass had reproduced successfully, in the standard bass-shiner ponds, they continued to reproduce each year thereafter during the experimental period. Reproductive success was more spotty in the bass-bluegill ponds. If bass do generally reproduce more regularly and more successfully in bass-shiner ponds, the reasons remain obscure.

Swingle and Smith (1943), in their experiments with bass and bluegills in Alabama, found that: "Large bass (1 pound or more) always failed to reproduce in ponds unless they had an adequate supply of small fish for food during the fall and spring months preceding the spawning period." The authors did not state what constituted an "adequate supply of small fish".

TABLE 6. RELATIONSHIP OF BASS REPRODUCTION TO THE RELATIVE ABUNDANCE OF SHINERS IN PROJECT PONDS

Pond	Year stocked	Years after stocking *§					
		1	2	3	4	5	6
Non-standard							
Myers†	1954	2	1 ξ	‖ 0	‖ 2	1	2
Standard							
Hatchery C	1955	0	3	1 ξ	2	‖ 2	.
Hatchery D	1955	0	2	2 ξ	2	‖ 2	≥ 1
Hatchery E	1955	0	0	0	2	3	≥ 1
Smith	1955	0	2	1	3	ξ 1	.
Swanson	1955	0	3	1 ξ	2	2	‖ ≥ 1
Newhart	1956	0	2	1	2	.	.
L. Hayes	1957	0 ξ	2	1	≥ 1	.	.

* Definition of symbols: ξ indicates total standing crop of shiners had fallen below about 15 pounds per acre;
‖ indicates shiners had disappeared.

§ The last year's data in each case came from early-summer rather than late-summer reproduction checks, thus more accurate estimates are not available.

† Shiners were restocked in Year 2, and all disappeared within 1 year thereafter.

Shiner populations diminished to a low level or disappeared in most of the project bass-shiner ponds during the experimental period. Table 6 contains data on the reproductive success of bass and standing crops of shiners. The data show that bass continued to reproduce after only few or no shiners were present. Therefore, if larger bass do require a supply of small fish in order to reproduce, as stated by Swingle and Smith, then presumably the smaller bass serve as prey.

Reproductive Success of Shiners Data on reproductive success of shiners are also summarized in Table 4. Shiners reproduced successfully, usually very successfully, in all ponds the year following stocking. Thereafter reproductive success apparently decreased in most ponds. This may have been due to a decrease in the brood stock, or to predation on shiner fry and fingerlings by the increasing number of bass present, or both. Except in the Hatchery E pond, in which bass failed to reproduce until 4 years after stocking, no successful shiner reproduction occurred 5 years after stocking.

As shown in Table 2, shiners were restocked in the Myers pond after those first stocked had disappeared. This second population disappeared within a year in spite of the fact that the restocking rate was high and that the shiners appeared to be in good condition when stocked.

Forney (1957) found that the bait ponds in which shiner reproduction was unsuccessful were characterized by consistent Secchi-disc transparencies of under 14 inches and by an absence of submerged aquatic vegetation. All project bass-shiner ponds had some submerged vegetation and usually transparencies greater than 14 inches. The least weedy, least transparent pond was Hatchery E which, however, maintained the highest standing crop of shiners. It seems clear, therefore, that the relatively poor reproductive success by the shiners, 4 or 5 years after stocking, was not due to lack of spawning sites.

Standing Crops

The data on standing crops of bass in the bass-shiner ponds are, on the whole, more reliable than those for the bass-bluegill ponds for reasons given in the section on data collection. Estimates of standing crops of bass in the bass-shiner ponds are summarized first and compared with similar estimates for the standard bass-bluegill ponds. Available data on standing crops of shiners are then presented, followed by a model of standing crops of original bass stock in unexploited bass-shiner ponds.

Standing Crops of Bass The data on the standing crops and harvests in bass-shiner ponds are summarized (Table 7) for all bass present and for those of harvestable size. The data are also classified according to whether the bass-shiner ponds were standard or non-standard and according to relative pond fertility.

Table 7. Estimated Standing Crops and Harvests of Bass in Ponds of Two Experimental Categories Annually after Stocking *

Experimental category	Relative pond fertility	Pond	Quantity stocked	Year 1		Year 2		Year 3		Year 4		Year 5 crop
				Crop	Harvest	Crop	Harvest	Crop	Harvest	Crop	Harvest	
Total standing crops and harvests												
Non-standard.....	Moderate	Myers	1	115	0	151	10	128	40	123	5	118
		Earl	?	40	..	..	..	..	..	..	..	..
Standard.....	High	Hatchery C	1	22	0	58	25	69	15	86	40	101
		Hatchery D	1	31	0	44	15	116	40	134	0	148
		Hatchery E	1	14	0	62	0	76	10	88	0	165
	Moderate	Smith	1	46	0	79	0	93	0	134	35§	112
		Swanson	1	38	0	61	35	93	20	125	45	109
	Low	L. Hayes	1	22	0	23	?	37	..	..	..	..
		Newhart	1	32	..	..	..	..	..	..	..	..
Standing crops and harvests of bass over 10.0 inches long												
Non-standard.....	Moderate	Myers	..	112	0	124	10	48	40	34	30	56
		Earl	..	40	..	..	..	..	..	..	..	..
Standard.....	High	Hatchery C	..	0	0	56	25	56	15	55	30	38
		Hatchery D	..	0	0	42	15	66	25	71	0	73
		Hatchery E	..	0	0	62	0	76	10	73	0	122
	Moderate	Smith	..	12	0	75	0	73	0	82	35§	6
		Swanson	..	0	20	55	30	51	10	60	40	48
	Low	L. Hayes	..	0	0	0	?	14	..	..	..	..
		Newhart	..	0	..	..	..	..	..	..	..	..

* Data in pounds per acre; crop inventories made in summer in Years 1 and 2, and in autumn thereafter.
§ May be an underestimate since pond was fished by neighborhood children in addition to owner's family.

The Myers pond contained the highest total standing crops consistently from 1 to 3 years following stocking and reached a maximum of about 150 pounds per acre. This pond was stocked with 170 age I+ bass per acre. Lowest total standing crops occurred consistently in the L. Hayes pond in which the population failed to reach 40 pounds per acre during the first three years following stocking. The low figures for this pond 3 years after stocking may have been due partly to fishing, data on which were not available.

Total standing crops of bass increased more or less regularly, with several exceptions. In the Smith and Swanson ponds, they decreased somewhat between 4 and 5 years after stocking. Both of these ponds had been fished moderately in the late summer. The bass populations may, therefore, not have had sufficient time to recoup these losses before the autumn inventories were made. The other exception was the Myers pond where the total standing crop of bass fell from about 150 to 120 pounds per acre during the last three years; this pond was apparently overcrowded with bass.

Total standing crops of bass appear to have been about equal in ponds of high and moderately high fertility within the standard bass-shiner category. The low standing crops in the Newhart and Hayes ponds may have been due to low fertility; growth rates were low in both.

Standing crops of harvestable bass in the standard bass-shiner ponds reached about 75 pounds per acre 3 years after stocking in two unfished ponds and from 50 to 60 pounds per acre in three fished ponds. It is not known whether the L. Hayes pond was fished; likely it was not. During and after this period the standing crops of harvestable fish obviously depended not only on growth and survival of the original stock but also on the amounts harvested and on recruitment.

Mean total standing crops of bass were considerably and consistently higher in the standard bass-shiner ponds than in standard bass-bluegill ponds (Table 8). One year after stocking the difference was about 50 per cent and it increased each year until it reached about 100 per cent 5 years after stocking. With respect to standing crops of harvestable bass, estimates in the bass-shiner ponds averaged 80 to 110 per cent higher than in the bass-bluegill ponds from 2 to 4 years after stocking, and about 60 per cent higher in the fifth year.

Wilcoxon's two-sample test (Steel and Torrie, 1960) was used to test the assumption that these differences in standing crops were significant. The test indicated significant differences between total standing crops of bass in the bass-shiner and bass-bluegill ponds 4 and 5 years after stocking and also between standing crops of harvestable bass 4 years after stocking. Generalization of this finding, to apply to non-project ponds, is risky since the ponds were not assigned strictly at random to the two categories. However, the higher mean standing crops in the bass-

Table 8. Comparison of Mean Standing Crops and Harvests of Bass in Standard Bass-Shiner and Standard Bass-Bluegill Categories *

Category	Quantity stocked	Year 1		Year 2		Year 3		Year 4		Year 5 crop
		Crop	Harvest	Crop	Harvest	Crop	Harvest	Crop	Harvest	
Total standing crops and harvests										
Bass-shiner	1 (7)	29 (7)	0	54 (6)	15	81 (6)	17	113 (5)	24	127 (5)
Bass-bluegill	1 (6)	19 (6)	4	34 (6)	9	52 (6)	3	52 (5)	0	63 (3)
Standing crops and harvests of bass over 10.0 inches long										
Bass-shiner	...	2 (7)	0	48 (6)	14	56 (6)	12	68 (5)	21	57 (5)
Bass-bluegill	...	0 (6)	4	26 (6)	9	31 (6)	3	32 (5)	0	35 (3)

* Data in pounds per acre; figures in parentheses represent number of ponds involved in each case.

shiner ponds occurred in spite of larger mean harvests (with one exception) in these ponds than in those of the bass-bluegill category.

Standing crops of shiners are discussed in the next section. It is shown there that shiner populations reached a low level 2 or 3 years after stocking in all ponds except Hatchery E and Newhart. Shiners disappeared in four of the ponds. Three of the ponds contained crayfish populations. The crayfish populations probably never had a density greater than 10 pounds per acre in Hatchery C and Hatchery D ponds; in Hatchery E pond the density was apparently somewhat larger than that, at least in 1958. The data indicate that standing crops of bass increased in ponds containing few or no shiners, crayfish, or other large vertebrate or invertebrate forage species. They increased in these forage-poor ponds in much the same way as did those in forage-rich ponds. It seems to follow that an abundance of larger forage animals, other than small bass, is not absolutely necessary in largemouth bass culture.

Standing Crops of Shiners Data on standing crops of shiners are incomplete for all ponds for reasons already given. However, the records of relative abundance indicate that in most ponds the shiner populations reached a peak about 2 years after stocking and declined thereafter. They were low in all but the Hatchery E pond in 1958.

The Hatchery E shiner population was inventoried, by draining the pond and recovering at least 95 per cent of the fish, in September 1958

and November 1960; standing crops were estimated to be 301 and 118 pounds per acre, respectively. The high abundance in this pond 3 to 5 years after stocking may have been due to an absence of small bass (which prey on shiner fry and fingerlings) until 1959. Shiner populations failed to build up in the Hayes pond, probably because of the mortality following stocking and the almost total lack of submerged vegetation, on which to deposit eggs, during the summer following stocking.

Forney (1957) raised golden shiners, from brood stock, in ponds similar to the project ponds. His results, summarized in Table 9, show

TABLE 9. STANDING CROPS AND HARVESTS OF GOLDEN SHINERS IN BAIT PONDS*

Type of pond	Standing crops and harvests§		
	Year 1		Year 2 crop
	Crop	Harvest	
Fertilized	170	60	360
Unfertilized	no data	0	90

* After Forney (1957).
§ Data in pounds per acre.

that shiner populations increased to quite a high level in fertilized ponds without supplemental feeding. The difference between standing crops of shiners in bait ponds and in bass ponds (assuming shiners maintain high standing crops in unharvested bait ponds 3 to 5 years after stocking) is likely due to bass predation.

Data in Table 10 show the number of years after stocking when shiner populations fell to a low level and finally disappeared. Standing crops fell to 15 pounds per acre or less within 4 years of stocking in five of seven standard bass-shiner ponds. Shiners disappeared within 5 years in three of five ponds, probably due to bass predation.[5]

STANDING CROPS OF UNFISHED ORIGINAL BASS STOCK Standing crops of original bass stock in unfished bass-shiner ponds in successive years may be estimated by the method used for such stock in bass-bluegill

[5] The three Hatchery ponds were each contaminated for several years by common suckers that entered as fry through pipe inlets. They were removed when captured. Standing crops of suckers were apparently never above 15 pounds per acre. The Newhart pond was slightly contaminated for at least two years with common shiners and creek chubs. Two large brown bullheads and a goldfish were removed from Smith pond. The other ponds were apparently not contaminated. None of the contaminants reproduced successfully. The author considers that these other fish had little effect on the dynamics of the bass and shiner populations.

Table 10. Number of Years after Stocking until Standing Crop of Shiners in Bass-Shiner Ponds Had Fallen to Less Than 15 Pounds per Acre and until the Shiner Population Had Disappeared *

Pond	Standing crop less than 15 pounds per acre	Population disappeared
Non-standard		
Myers§	3	3
Standard		
Hatchery C	3	4
Hatchery D	3	4
Hatchery E	(>5)	(>5)
Smith	4	(>5)
Swanson	3	5
Newhart	(>4)	(>5)
L. Hayes	1	(>3)†

* Data in parentheses indicate that population had not fallen to stated level when last inventory was made.
§ One attempt at restocking, in the third year, failed.
† A few shiners remained.

ponds (Regier, 1963a). The assumptions, necessarily somewhat different, are as follows:

1. Bass were stocked as fingerlings about September 15 at 100 per acre together with adult shiners at 400 per acre.
2. There was no fishing mortality. Annual natural mortality of bass was 17 per cent for the first 2.3 years and 6 per cent thereafter.
3. Bass growth rates were equal to the mean growth rates in standard bass-shiner ponds.

Table 11 contains standing crop estimates based on these assumptions; the model for standard bass-bluegill ponds (from Regier, 1963a) is included for comparison. The models indicate that standing crops of unfished original bass stock would have been considerably higher in average project ponds of the standard bass-shiner category than in those of the standard bass-bluegill category. Differences can be traced to higher survival and somewhat faster growth in the bass-shiner ponds. The author considers that this finding may be generalized to apply to the average of the better-constructed, better-managed, two-thirds of warm-water farm ponds in New York.

Harvests

Estimates of harvests were, on the whole, somewhat more reliable for bass-shiner than for bass-bluegill populations since catch records

TABLE 11. MODELS OF STANDING CROPS OF BASS IN STANDARD BASS-SHINER AND STANDARD BASS-BLUEGILL CATEGORIES, IN THE ABSENCE OF FISHING, ANNUALLY AFTER STOCKING

Statistic	Years after stocking					
	0	1	2	3	4	5
Bass-shiner						
Number per acre	100	86	71	63	60	56
Mean weight	0.006	0.32	0.76	1.15	1.38	1.55
Pounds per acre	1	28	54	72	83	87
Bass-bluegill						
Number per acre	100	82	66	53	42	34
Mean weight	0.006	0.29	0.63	0.92	1.22	1.52
Pounds per acre	1	24	42	49	51	52

were generally more detailed. Data on harvests in bass-shiner ponds are discussed first and then several models of optimum harvest rates are developed.

SUMMARY OF HARVEST DATA Tables 7 and 8 summarize the bass harvest data from the bass-shiner ponds. The estimates were rounded to the nearest 5 pounds. The author considers these data quite reliable, with the one exception noted in Table 7.

No bass were reported harvested in any of the ponds during the first year after stocking; cooperators apparently followed instructions in this respect and waited until the bass had spawned successfully at age II+. Fishing pressure was very light in the Smith pond for the first four summers, and apparently no fish were removed during this period. In the Hatchery E pond, most fish captured during a limited amount of angling were returned to the pond; this explains the low or zero harvests.

Part of the harvests in Hatchery C, Hatchery D, Swanson and Myers ponds 4 and 5 years after stocking consisted of sub-harvestable bass. Mostly between 9 and 10 inches long, they were removed in an effort to reduce the population and thus improve growth rates. Judging from subsequent inventory data, the harvests of smaller bass had no adverse effect on the bass populations as a whole.

The largest harvests were made in the Swanson pond; from the second through the fifth summer after stocking, about 100 pounds per acre were removed. About 80 pounds per acre were removed during the same period from the Hatchery C pond. Both ponds could have supported larger harvests, judging from the estimated standing crops during this period. Comparison of actual harvest rates (Table 8) with

Table 12. Schedules for Optimum Harvests, for Average Project Ponds, of Original Stocks of Bass in Standard Bass-Shiner and Standard Bass-Bluegill Categories

Category	Harvest quota	Weight or number per acre harvested each year after stocking *						
		1	2	3	4	5	6	Total
Constant number per acre to be harvested each year over specified period								
Bass-shiner.....	22 fish, starting in Year 2	0	17	25	30	0	..	72
	30 fish, starting in Year 3	0	0	34	41	0	..	75
Bass-bluegill...	11 fish, starting in Year 2	0	7	10	13	17	3	50
	14 fish, starting in Year 3	0	0	13	17	20§	..	50
Constant weight per acre to be harvested each year over specified period								
Bass-shiner.....	23 pounds, starting in Year 2	0	30	20	17	0	..	67
	38 pounds, starting in Year 3	0	0	33	28	0	..	61
Bass-bluegill...	12 pounds, starting in Year 2	0	18	13	10	8	0	49
	16 pounds, starting in Year 3	0	0	17	13	11	0	41

* Where constant number is to be harvested, data for each year under this heading given in weight; where constant weight is to be harvested, data given in numbers. Quota on original stock ceases after fourth year for bass-shiner category, after fifth year for bass-bluegill category.

§ Not quite enough original stock present to fill quota.

optimum harvest rates for bass in bass-shiner ponds (Table 12) indicates that project ponds as a whole could have supported larger harvests.

Optimum Harvest Models It was shown in the section on reproduction that bass of the first year class spawned in the bass-shiner ponds usually attained harvestable size in good numbers during the fifth year after stocking. It follows that original bass stock must usually provide all or almost all the fishing during the first four years of such a population's existence.

Table 12 gives models of optimum harvest for standard bass-shiner populations. For comparison, models applicable to standard bass-bluegill populations, taken from Regier (1963a, Table 19), are included. The models for bass-shiner populations are based on the same three assumptions postulated in determining standing crops of unfished original bass stock, plus the following:

4. Harvests were made in midsummer, about August 1.
5. Harvests of original stock were unselective with respect to size of individual fish.

The precautions to be borne in mind in interpreting these models are essentially those stated for the bass-bluegill models by Regier (1963a).

The models indicate that, starting in Year 2, about 22 bass were

available for harvest each year in the "average" bass-shiner pond among those studied. Starting in Year 3 about 30 were available. Using a quota based on weight, 23 pounds per acre were available annually beginning in Year 2, and 38 pounds per acre beginning in Year 3.

The models indicate that the average standard bass-shiner population could have supported annual bass harvests about twice as large as those for the average bass-bluegill populations of the standard category. These findings may be generalized only with caution to apply to non-project ponds, since the ponds studied were not randomly chosen nor were they assigned at random to the various categories once chosen. Furthermore, the bass stock came from different sources in the two categories. On the other hand, the author has no evidence that the bass-shiner ponds were generally more suitable habitats for bass than the bass-bluegill ponds, with respect to environmental factors other than the forage species present. Nor is there any reason to believe that the bass stocked in the bass-shiner ponds were genetically superior to those stocked in bass-bluegill ponds.

The author believes that in New York standard bass-shiner populations generally may produce higher crops of harvestable bass, perhaps even twice as high, than standard bass-bluegill populations. In terms of total weight (including both bass and bluegills) most bass-bluegill populations likely produce greater amounts of harvestable fish than do bass-shiner populations, perhaps twice as high (see Discussion).

If a pond owner were given a choice between standard bass-bluegill and standard bass-shiner stocking policies for his pond, assuming the pond suitable for both, which should he choose? On the basis of the findings of this study, the pond owner interested primarily in sport fishing for bass should choose bass and shiners. The pond owner interested in the greatest total harvests, or in maximizing sport and pan fishing, or both, should choose bass and bluegills.

Population Condition

Population condition in bass-bluegill ponds was discussed by Regier (1963a). Individual species populations were described either as "crowded" or "uncrowded". If so many fish of a species were present in a pond that their condition (plumpness) was poor or that their growth rates were low, that population was considered crowded. If the converse was true the population was considered uncrowded. These terms and definitions are also used in the following discussion of bass populations in bass-shiner ponds.

All the standard bass-shiner populations, with one exception, showed evidence of crowding 4 years after stocking. The exception was the Hatchery E pond, in which reproduction was delayed and a high standing crop of shiners was present; even in this pond bass plumpness apparently decreased considerably from Year 4 to Year 5.

Table 13. Estimated Mean Weights of 10-inch Bass in Bass-Shiner Ponds

Pond	Years after stocking			
	2	3	4	5
Non-standard				
Myers*	0.52	0.46	0.50	0.49
Standard				
Hatchery C	0.57	0.51	0.51	0.48
Hatchery D	0.66	0.51	0.47	0.47
Hatchery E	0.60	0.58	0.57	0.52
Smith	0.57	0.50	0.49	0.47
Swanson	0.56	0.50	0.48	0.49
Newhart	0.48	§	0.56	....
L. Hayes	0.50	0.53	....	....
Mean	0.56	0.52	0.51	0.49

* The datum for Year 1 was 0.59.
§ No data available.

Table 13 contains data on bass plumpness in bass-shiner ponds. The data are estimates of population mean weights of bass 10 inches long. The method of deriving such estimates was discussed by Regier (1963a). Within-population mean weights of 10-inch bass varied from 0.47 to 0.66 pound in the standard bass-shiner ponds. Taking 0.55 pound as the usual weight for bass of this size (Regier, 1963a), the range extended from 85 to 120 per cent of it. Comparable figures for bass in standard bass-bluegill ponds were 82 and 113 per cent.

Plumpness of bass generally decreased as the populations in bass-shiner ponds aged; the L. Hayes and Newhart populations were exceptions. Over-all means decreased from 0.56 in Year 2 to 0.49 in Year 5.

Was plumpness of bass related to population density? Spearman's procedure (Steel and Torrie, 1960) was used to compute rank correlation coefficients between estimated population mean weights at 10 inches and total standing crops in pounds per acre for each year after stocking. Only the data from highly and moderately fertile ponds of the standard category were used, in an attempt to control as many variables as possible. The hypotheses that each of the rank correlation coefficients did not differ significantly from zero were tested against the alternate hypotheses that the coefficients were greater than zero. All four coefficients were negative, but none differed significantly from zero.

If plumpness were in fact unaffected by population density, then the two variables used in the preceding test would be positively corre-

lated, since estimates of mean weight were used in calculating both variables. Under these circumstances the likelihood of getting a negative correlation purely by chance with any series of data is less than ½, and that of getting four out of four negative correlations is, therefore, less than $(\frac{1}{2})^4$, or less than 6 per cent. The author concluded that plumpness was affected adversely by population density in bass populations in the project's standard bass-shiner ponds.

How did the plumpness of bass stocked with shiners compare with that of those stocked with bluegills? Means for the standard bass-shiner ponds were summarized with similar data for bass-bluegill ponds by Regier (1963a, Table 22). Little difference was noted between the two groups 2 years after stocking, but small differences were apparent 3 to 5 years after stocking. The author does not consider these differences significant.

If bass plumpness generally decreases after Year 2 in bass-shiner ponds, then reducing the density of bass populations becomes a management problem. One way of attacking it might be as follows. Crowding first seems to become severe about 4 or 5 years after stocking when quite a number of bass about 10 inches long are usually present, as well as some over 15 inches. If some of the larger bass are returned to the pond when caught, they may aid in controlling the smaller bass, since a 14.5-inch largemouth bass can swallow a 7.7-inch bass according to Lawrence (1958). The 9- to 14-inch bass will then bear the brunt of the harvest. Perhaps both sport and harvests can be maximized in bass-shiner ponds in this way.

An ecological implication of the inverse relationship between population density and plumpness is that bass are not very effective as cannibals. All the crowded bass populations had numerous smaller bass present on which the larger bass might have preyed.

Pond Owner Reactions

Bass and shiners were stocked in 10 ponds; in one of these all fish died within 1 year. Three of the remaining nine ponds belonged to Cornell University and six to private cooperators.

Five of the private cooperators showed mild to moderately strong interest in the fish; one showed strong interest. None expressed dissatisfaction. Apparently the bass were valued primarily as sport and only secondarily as food.

DISCUSSION AND CONCLUSIONS

Over the last 50 years, scores of American fishery biologists have undertaken investigations of pond populations containing bass and bluegills. On the other hand, few have studied the bass-shiner combination

in farm ponds. Thirty years ago biologists studying methods of rearing bass in Federal hatcheries recommended golden shiners as a forage species. Periodically thereafter one finds references to the golden shiner as the near-ideal forage species for bass. In spite of this it was generally not considered to be a suitable fish for farm-pond stocking, largely because it was not suitable for human consumption.

Apparently pond biologists assumed that pond owners seriously desired both sport and food production in their ponds. It was clear that a bass-shiner combination would support moderate sport fishing (Swingle, 1952) but that it would provide no panfishing and only relatively low food production. Thus the bass-shiner combination was deemed less desirable than the bass-bluegill; one did not have to undertake experiments to prove the obvious.

The present author agrees that well managed (i.e., "balanced") bass-bluegill populations provide more sport (including panfishing a-sport) and food than bass-shiner populations. But he rejects the assumption that most New York pond owners seriously desire a maximum of both sport and food production. Most of them desire moderate amounts of sport fishing, preferably for bass, and are little interested in the pond as a source of food. Perhaps the bass-shiner combination would provide enough sport fishing in such cases.

It also seems clear that most New York pond owners prefer to spend a minimum of time managing their ponds for fish. There are usually other tasks to be done, other hobbies to be pursued, and natural waters nearby that may be fished. Therefore, another criterion on which to base a choice between bass-bluegills and bass-shiners is ease of management. The bass-shiner combination appears to be easier to manage, particularly in the smaller, shallower, weedier ponds of the State.

It follows that stocking with the bass-shiner combination should be encouraged in many New York ponds on a trial basis. Following is a brief review and discussion of the evidence on which this conclusion is based. Observations were made on bass-shiner ponds stocked according to three different formulae; however, because two of these were not replicated, the discussion will be largely restricted to those stocked with 100 fingerling bass and 400 adult shiners per acre. Unless stated otherwise, all references to the bass-bluegill combination are to the standard New York formula of 100 bass and 1,000 bluegill fingerlings per acre, stocked during the same calendar year.

Population Dynamics

In the bass-shiner ponds, mean bass survival rates in the absence of fishing were about 83 per cent per year for the first 2.3 years, and about 94 per cent for the next 2.7 years. Corresponding estimates for the bass-bluegill ponds were 80 per cent per year for the first five years.

Some original shiners were usually present in a pond 2 years after stocking, but few or none in the third year.

On the average, the bass grew somewhat more rapidly in the bass-shiner ponds as was also found by Ball (1952) for Michigan ponds. This was true for both the original stock and the first year class spawned in project ponds. The more rapid growth rates in the bass-shiner ponds occurred in spite of the fact that standing crops of bass in these ponds were considerably higher than those in the bass-bluegill ponds.

Shiners failed to become too large for the bass present in the ponds to feed on them.

Bass usually reproduced first at age II+ in bass-shiner ponds as in bass-bluegill ponds. Thereafter bass reproduction seemed to occur more regularly in the shiner than in the bluegill ponds. Bass continued to reproduce in ponds where shiners had disappeared. Reproductive success of shiners was usually highest the year following stocking and then decreased gradually. The decrease may have been due to both a dwindling of the shiner brood stock and predation on shiner fry and fingerlings. All experimental ponds seemed to contain sufficient aquatic vegetation on which shiners could spawn.

Standing crops of bass were consistently and considerably higher in the bass-shiner than in the bass-bluegill ponds. Both total and harvestable standing crops of bass averaged about 1.5 to 2.1 times as high in bass-shiner ponds as in bass-bluegill ponds in the second through fifth years after stocking. The differences seemed significant.

Shiner populations in most bass-shiner ponds apparently reached a peak about 2 years after stocking and declined fairly rapidly after that. Five years after stocking, most shiner populations were either at a low level (less than 15 pounds per acre) or absent. Total standing crops of bass continued to increase after shiners disappeared.

These findings concerning shiners are similar to those of Swingle (1949) for golden shiner-largemouth bass and golden shiner-bluegill-largemouth bass ponds in Alabama. However, they contrast with those of Krumholz (1950) for Indiana ponds.

According to project findings the bass-shiner populations eventually became bass-only populations. Swingle (1949, 1952) also investigated bass-only populations and found that, stocked at 100 fingerlings per acre, they supported average annual catches of 42 pounds per acre over (presumably) a 3-year period. He considered 42 pounds per acre per year as inadequate production.

With one exception, bass populations in all project bass-shiner ponds showed crowding 4 years after stocking, and bass became progressively less plump as a result. Thus, 10-inch bass averaged about 12 per cent less in weight 5 years after stocking than they did 2 years after stocking.

Presumably, proper harvest methods would permit bass to retain normal plumpness.

The salient points with respect to bass-shiner populations in New York ponds are:

1. Bass survival and growth rates tend to be somewhat greater than in bass-bluegill ponds, and bass reproductive success is somewhat more regular in the bass-shiner ponds; therefore, standing crops of bass tend to be considerably higher in bass-shiner ponds than in bass-bluegill ponds.
2. Shiner populations reach a peak, then decline and probably disappear in most ponds.
3. Bass populations remain high after shiner populations decline, at least for several years, but bass become less plump if lightly harvested.

Possible Harvests

Table 14 contains a summary of optimum harvest rates for the original stock in average bass-shiner and bass-bluegill populations. The summary is abstracted from Regier (1963a, Table 19) and Table 12 of this paper. Optimum harvest of original stock is here defined as the maximum weight of a particular species that can be harvested between the time when the fish reach harvestable size and the time their progeny reach harvestable size, with the added condition that annual harvests must be equal.

Table 14. Optimum Harvest Rates, for Average Project Ponds, of Original Stocks of Bass and Bluegills in Standard Bass-Shiner and Standard Bass-Bluegill Categories

Harvest quota*	Number per acre harvested each year after stocking						
	1	2	3	4	5	6	Total
Bass-shiner							
Bass: 23 pounds, starting in Year 2.....	0	30	20	17	0	...	67
Bass-bluegill							
Bass: 12 pounds, starting in Year 2.....	0	18	13	10	8	0	49
Bluegills: 38 pounds, starting in Year 1..	317§	141	106	0	...	...	564

* Represents constant weight to be harvested each year. Bass quotas start in Year 2 to give bass an opportunity to reproduce. Quota on original stocks ceases after fourth year for bass in bass-shiner category, after fifth year for bass in bass-bluegill category, after third year for bluegills.

§ Most of these will be less than 6.5 inches long.

Table 14 may be interpreted as follows. Somewhat above-average New York ponds should provide annual bass harvests of about 23 pounds per acre starting in Year 2 if stocked with bass and shiners. If stocked with bass and bluegills, annual bass harvests should be about 12 pounds per acre starting in Year 2; bluegill harvests should be about 38 pounds per acre starting in Year 1. Thus *bass harvests* should be about twice as large in bass-shiner ponds as in bass-bluegill ponds, but *total harvests* should be about twice as large in bass-bluegill ponds.

In the preceding section, reference was made to Swingle's (1952) findings that bass-only populations supported harvests of 42 pounds per acre per year. This rate is almost twice as high as could be supported by project bass-shiner populations, at least in the first four years after stocking. Swingle felt that production of 42 pounds of fish per acre per year was too low. For Alabama pond owners interested in the greatest possible food production as well as sport, the figure is admittedly low. But a large proportion of New York pond owners have little interest in these fish as food and are satisfied with moderate amounts of sport fishing for bass. Likely the bass-shiner combination would supply enough fishing for many and probably most New York pond owners. This may not be the case in the future if interest in pond fishing and management increases markedly.

Management Methods and Costs

Bass and bluegills may be obtained from government sources through well established channels. However, the pond owner must obtain shiners from private sources which he must find for himself. Also, he must be able to recognize the golden shiner or he may receive a substitute bait fish. Most local bait dealers handle adult golden shiners (2.5 to 4 inches) suitable for stocking in farm ponds. Golden shiners could be reared in local farm ponds for transplanting into bass-shiner ponds. Methods of rearing shiners have been described by Forney (1957).

One of the main reasons why weed control is practiced in bass-bluegill ponds is to reduce cover for small bluegills. Such a reason does not exist in bass-shiner ponds since shiners tend to disappear even if aquatic vegetation is present. Actually, the shiners need some vegetation on which to spawn. Thus intensive weed control, whether by fertilization or by chemical and mechanical means, is not so important and in fact probably undesirable with the bass-shiner combination. But the pond should be kept sufficiently open to permit fishing and any other uses that the owner desires.

If bass can thrive in ponds containing shiners and some aquatic vegetation, then the bass-shiner combination would seem to be a logical choice for the smaller, shallower New York ponds where bluegills are almost certain to become a problem. But it would also be desirable to

try this combination in the larger, deeper ponds whose owners are clearly not interested in bluegills.

Winterkills are not infrequent in the smaller, shallower ponds in New York. Apparently bass populations are more apt to be winterkilled completely than bluegills. Thus it is usually considered necessary to poison or otherwise reclaim a partially winterkilled bass-bluegill population to destroy bluegill survivors before the pond is to be restocked. Reclaiming after a winterkill would likely be unnecessary for a bass-shiner pond, and survival of some shiners would presumably be an advantage at restocking. For these reasons, the bass-shiner combination would appear to be more suited than bass and bluegills for New York farm marshes of the type described by Emerson (1961).

Bass became less plump as they increased in number and the shiners decreased in the bass-shiner ponds. The bass in bass-bluegill ponds also tended to become less plump as the fish became older and more numerous. In the bass-shiner ponds crowding first became severe about 4 or 5 years after stocking. At this time there were usually quite a number of bass present about 10 inches long, as well as some over 15 inches long. Perhaps such smaller bass, say those 9 to 14 inches long, should be selectively harvested and larger bass returned. The larger bass could then continue to maintain predator pressure on the smaller ones and so reduce their numbers. The presence of the larger bass in the pond would also serve to retain owner interest. This method of harvesting might serve to maximize both sport and harvests in bass-shiner ponds.

Properly maintained ponds in New York may be managed for bass and shiners at an additional cost of about $20 per acre per year (Regier, 1961). This is about half the cost of managing bass-bluegill ponds. If a pond owner builds a 1-acre pond exclusively for bass-shiner fishing and plans to pay off the total cost in equal payments over 20 years, then his payments would be about $210 a year or about 90 per cent of the cost for a comparable bass-bluegill pond.

As has been pointed out, well managed bass-bluegill ponds should provide about twice as much fishing (including both sport and panfishing) as bass-shiner ponds. Thus the pond owner who builds a pond expressly for fishing would get considerably more return for his money if he stocked and managed bass and bluegills. On the other hand, the owner who builds a pond for a number of reasons and desires a moderate amount of bass fishing at minimum cost would be most likely to achieve his objective with the bass-shiner combination. This combination should be more advantageous than the bass and bluegills for the pond owner who is not particularly interested in bluegills and whose pond is quite small and fairly shallow with a surface temperature that rises above about 73° F. in summer. The author believes that this is the case with respect to most warm-water farm ponds in New York.

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ECOLOGY AND MANAGEMENT OF CHANNEL CATFISH IN FARM PONDS IN NEW YORK[1]

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ABSTRACT

Experiments with channel catfish were conducted in farm ponds in central New York. This species does not appear to hold much promise for general stocking in New York farm ponds because it is difficult to produce cheaply and in large numbers for stocking purposes; survival and reproduction of stocked fish were poor in most project introductions; and the unpredictability of survival and of reproduction implies that harvest quotas would be unpredictable.

This is the third of a three-part study (see Regier, 1963a, 1963b) whose objective was to construct a factual and reasoned basis for a fish-stocking and management policy applicable to warm-water farm ponds in New York. It concerns experiments with channel catfish (*Ictalurus punctatus*).

Almost 50 years ago, the Kansas Department of Fish and Game published a bulletin on pond construction, stocking and management (Dyche, 1914) in which the author stated:

> "The channel catfish is the most satisfactory combination of a good food and game fish in the state of Kansas. . . . It is very unfortunate that such a popular and valuable native fish will not breed in ponds."

Sometime thereafter it was noted that channel catfish could use nail kegs as spawning sites in small ponds (Clapp, 1929). Another difficulty, that of rearing fingerling catfish for introduction into ponds, was commented on by Clemens and Sneed (1957) as follows:

> "Most hatcheries have reported difficulty in spawning channel catfish and some have failed completely because of fragmentary information and lack of understanding of the various aspects involved."

When channel catfish were available and were stocked in ponds, growth and production were apparently satisfactory (Brown, 1951). They have been recommended for farm ponds on the Great Plains and in the Midwest either alone or in combination with one or more species of centrarchids. Concerning stocking rates, Toole (1950) recommended 75 per acre for Texas, while Krumholz (1950) and Tiemeier, Way and Schoonover (1951) recommended 200 per acre for Indiana and Kansas, respectively.

Little has been reported concerning special management required to produce and maintain satisfactory channel catfish populations in farm ponds, although Swingle (1959) recently described experiments with

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[1] Derived from a Ph.D. thesis submitted to the Graduate School at Cornell University in 1961. This study is a contribution of Federal Aid in Fish and Wildlife Restoration Project F-17-R. Personal acknowledgements are made elsewhere (Regier, 1963a).

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commercial production in Alabama ponds. Krumholz (1950) made some management suggestions for Indiana ponds:

> "The channel catfish grows well in ponds in Indiana and weights of more than two pounds are attained within 20 months of stocking as fingerlings. That species, however, will not spawn in ponds unless special spawning facilities are provided. Such facilities as a nail keg or a 10-gallon milk can lying on its side about 18 inches underneath the water surface are satisfactory. Once the channel catfish have spawned, the spawning facilities can be removed and there will be no further reproduction until it is wanted. In this way the numbers of fish can be controlled."

Experiments with channel catfish under the present project were begun in 1952. At that time few, if any, farm ponds in New York had been stocked with this species. The closest hatchery producing channel catfish was apparently in Missouri. Information available on catfish population dynamics in farm ponds was essentially that outlined above. The objectives of the experiments were to determine the survival, growth, harvestability, and reproductive potential of channel catfish as a single species in farm ponds in central New York.

MATERIALS AND METHODS

General methods were given by Regier (1963a); those that pertained especially to the work on catfish[3] are described here.

Experimental Categories

Project personnel stocked catfish in 12 ponds near Ithaca (N. Y.). Part of the stock came from Oneida Lake in New York State and the remainder from a hatchery in Missouri. The two stocks may not have been equally well adapted to conditions in the project ponds. Ponds containing catfish from Oneida Lake are thus considered to be in a different category from those containing catfish from Missouri, and differences between them are explored briefly in subsequent sections.

Experimental Ponds

General characteristics of project ponds were given by Regier (1963a). Table 1 contains more detailed information on the ponds stocked with catfish.

Twelve ponds were used in these investigations. Four (Bloom, Hammond, Marion, and Swanson) were actually marshes (see Emerson, 1961) containing permanent pools with maximum depths of about 7 feet. The Hammond pond fluctuated in surface area from about 0.2 to 2 acres; the Swanson pond, between about 0.25 and 1 acre. The Bloom and Marion ponds also fluctuated markedly in surface area. The other eight ponds did not fluctuate so markedly.

Four ponds (Johnson, North Cronk, North Shannon, and South

[3] "Catfish", as used in this study, refers to channel catfish.

Table 1. Characteristics of Project Ponds Stocked with Channel Catfish According to Strain of Stock

Pond	Mean area (acres)	Age of pond at stocking (years)	Period studied	Footnote remarks
Missouri stock				
Bloom	1.0±	1	1952–1955	b, c
Hammond	0.5	1	1952–1960	a, b
Hillendale	0.2	1	1953–1955	d
Marion	1.0±	1	1952–1953	b, d
North Cronk	0.2	2	1952–1953	e
Washburn	0.25	0	1953–1955	a, c
Oneida Lake stock				
Johnson	0.2	2	1952–1953	
North Shannon	0.2	6	1952–1955	f
South Cronk	0.35	2	1952–1960	a
Swanson	0.3	2	1952–1961	a, g
DeGraff	0.3	?	1955–1956	h
Frost	0.7	?	1955–1960	a

a Continued under study for five or more years.
b A farm marsh (see text).
c Large watershed area drained through pond.
d Pond seriously contaminated with yellow perch, brown bullheads and pumpkinseeds at time of stocking.
e Pond drained by SCS in winter of 1953–54.
f Pond contaminated with brown bullheads and bluegills.
g Pond contaminated with fathead minnows and crayfish.
h Pond had a history of fish kills from unknown causes.

Cronk) were on the Hector Grazing Area managed by the U. S. Department of Agriculture. The other eight were privately owned.

Data on pond fertility are less complete than those for most ponds discussed in the previous papers. All ponds were judged to be at least moderately fertile, with the Swanson and South Cronk ponds highly fertile.

Stocking Data

In the spring of 1952 some adult catfish were captured in Oneida Lake and placed in a pond at the Cornell Fish Hatchery. The fish reproduced successfully, and later in the summer the fingerlings were stocked in five ponds. In the spring of 1955 additional adult catfish were captured in Oneida Lake and stocked in two ponds.

Fingerlings from Missouri were obtained in December 1952 and again in September 1953. The 1952 lot had been transported by truck in a relatively small amount of water and the fish were stocked in three ponds when these had already begun to freeze over. Perhaps these pre-

TABLE 2. STOCKING RECORD FOR CATFISH IN PROJECT PONDS

Pond	Strain of stock	Fish stocked		Mean total length (inches)	Date stocked
		Total	Number per acre		
Bloom	Missouri	200	200	*	Dec. 1952
	Missouri	200	200	2.7	Sept. 1953
Hammond	Missouri	200	400	*	Dec. 1952
	Missouri	200	400	2.7	Sept. 1953
Hillendale	Missouri	100	500	2.7	Sept. 1953
Marion	Missouri	300	300	*	Dec. 1952
North Cronk	Oneida Lake	125	600	2.9	Sept. 1952
	Missouri	100	500	*	Sept. 1953
Washburn	Missouri	133	500	*	Sept. 1953
Johnson	Oneida Lake	75	300	2.9	Sept. 1952
North Shannon	Oneida Lake	75	300	2.9	Sept. 1952
South Cronk	Oneida Lake	125	350	2.9	Sept. 1952
Swanson	Oneida Lake	91	300	2.9	Sept. 1952
	Missouri	91	300	2.7	Oct. 1953
Frost	Oneida Lake	13	40	21.8§	April 1955
DeGraff	Oneida Lake	13	20	21.4†	April 1955

* Fingerlings; no length data available.
§ Adults ranging from 18.0 to 28.2 inches (2.2–10.5 pounds).
† Adults ranging from 15.5 to 28.3 inches (1.2–10.5 pounds).

sumably adverse conditions caused the high mortality in these groups (see section on survival). The 1953 lot from Missouri arrived in better condition.

In 1953 catfish were stocked in four ponds that had been stocked in 1952 (i.e., Bloom, Hammond, North Cronk, Swanson) because 1953 inventories indicated complete mortality of the earlier lots. Later inventories showed that mortality of the 1952 Oneida Lake lot in the Swanson pond had not been complete, but that mortality of the 1953 Missouri lot in this pond was high and that it disappeared within four years of stocking. Except for the limited period in the Swanson pond, no ponds contained catfish of more than one lot at the same time.

Stocking rates in the 10 ponds stocked with fingerlings varied from about 200 to 600 per acre, with most between 200 and 400 per acre (Table 2). The stocking rates are based on number per acre of estimated mean surface area during the growing season. The estimates of mean

area are not very reliable in view of the fluctuations in water level that occurred.

Stocking rates recommended in some other states have been mentioned. Most of the project ponds were stocked at considerably higher rates because they were stocked on the basis of maximum area rather than mean area during the growing season.

Data Collection

Types of data collected and general collection methods were generally similar to those described by Regier (1963a). Inventories were usually made in June, occasionally in July, in the years 1953 to 1957. From 1958 to 1960, inventories were made in September or October, with a few in late August. Farm marshes are difficult to inventory in early summer due to high water flooding the shallows; as a result, some of the population estimates made under such conditions are not very reliable.

The ponds were visited during 1959 and 1960, chiefly to determine whether reproduction had occurred. It was necessary to use large seines since no young-of-the-year catfish were captured by shore seining with 10-foot seines except on one occasion. Length-frequency data were collected for all catfish caught during the reproduction checks; also fish of a representative sample including all size classes were weighed individually. Thus growth as well as reproduction data were available after 1958; in several ponds population estimates were also made.

The author considers growth and reproduction data to be reliable; however, a few of the population estimates are not so reliable, especially those for the first few years. Data on standing crops, in pounds per acre, are inaccurate to some extent because they are based on three estimates (number in population, mean weight, and mean area of pond) each of which was subject to error.

RESULTS

Findings of the study, in terms of survival, growth, reproduction and yield are given under separate topics. Pond-owner reactions are also summarized.

Survival of Original Stock

Table 3 shows the number of originally stocked catfish that survived to the time of inventory during years after stocking. Minimum estimates derivable from inventory data are used instead of Petersen estimates which would have been less reliable because of the nature of the data.

For each of the four lots of catfish used in stocking project ponds the estimated survival to age II+ is shown in Table 4. Apparent total mortality followed, within 2 years of stocking, in at least one pond in each case. Good to fairly good survival occurred in at least one pond

TABLE 3. NUMBER OF SURVIVORS AND HARVESTS OF ORIGINAL STOCK OF CATFISH ANNUALLY AFTER STOCKING *

Pond	Year 1		Year 2		Year 3		Year 4		Year 5		Year 6		Year 7		Year 8
	Survivors	Harvest	Survivors	Harvest	Survivors	Harvest	Survivors	Harvest	Survivors	Harvest	Survivors	Harvest	Survivors	Harvest	survivors
Hammond §	>47	1	46	0	>17	0	17	0	17	0	17	3	14	..	..
Hillendale	>14	2	>1	..	..	..	..	..	..	..	..	..	..	..	..
Washburn	75	1	74	0	74	10	46	18	1	0	1	..	..	..	..
Johnson	7	0	5	1	..	..	..	..	..	..	..	..	..	..	..
North Shannon	60	0	33	8	25	..	..	..	..	..	..	..	..	..	..
South Cronk	82	0	77	3	70	0	29	5	18	0	16	5	>3	..	..
Swanson †	48	0	48	19	29	4	19	3	13	0	10	2	8	2	6
Swanson ‡	>5	0	5	0	4	0	0	..	..	..	..	..	..	..	..
Frost	12	0	12	0	10	0	>4	..	..	..	..	..	..	..	..

* All plantings not listed suffered total mortality within 1 year after stocking.
§ Represents lot stocked in September 1953.
* Represents Oneida Lake stock; all catfish surviving in Year 8 died the next winter.
‡ Represents Missouri stock.

Table 4. Estimated Survival, to Age II+, of Original Stock of Catfish According to Strain and Time of Stocking

Pond	Survival in per cent
Missouri—December 1952	
Bloom*	0
Hammond*	0
Marion*	0
Missouri—September 1953	
Bloom*	0
Hammond	23
Hillendale*	>1
North Cronk*	0
Washburn	56
Swanson*	5
Oneida Lake —September 1952	
Johnson*	7
North Cronk*	0
North Shannon§	44
South Cronk	62
Swanson	53
Oneida Lake—April 1955	
DeGraff*	0
Frost	92

* Experiments discontinued because of high or total mortality.
§ Experiment discontinued because of severe contamination with brown bullheads and bluegills.

for three of the four lots; the one exception was the 1952 lot from Missouri in which mortality was complete. A possible reason for this high mortality has been given in the section on stocking. Best survival occurred in the Frost pond stocked with adult fish from Oneida Lake. Catfish from the same lot were also placed in the DeGraff pond but died the following year from unknown causes. The DeGraff pond had a record of summerkills of this sort with other species. The hypothesis that Missouri fingerlings are as suitable for stocking in New York ponds as Oneida fingerlings cannot be rejected on the basis of these data.

From an over-all viewpoint, catfish mortality during the two years following stocking was either very high or complete for nine of the 14 fingerling introductions and for one of the two introductions of adults. This is a high failure rate, and the causes of the mortality are not known.

The oldest age attained by catfish stocked as fingerlings in project ponds was just short of 9 years, in the Swanson pond. Perhaps some of

those in Hammond pond or South Cronk pond eventually reached greater ages.

Did some year classes spawned in the ponds also suffer heavy mortalities within their first two years of life? Apparently not. Catfish reproduced successfully in four ponds. When the experiments were terminated, both yearlings and 2-year-olds were present in two ponds, and yearlings were present in a third pond. Only young-of-the-year were present in the fourth pond. There was thus no evidence to indicate that complete mortality had followed any successful hatch of a catfish year class.

GROWTH RATES

Growth data on the catfish originally stocked in project ponds are summarized (Table 5) as mean weights for population samples at the

TABLE 5. SAMPLE MEAN WEIGHTS FOR CATFISH OF ORIGINAL STOCK AT TIME OF INVENTORY ANNUALLY AFTER STOCKING *

Pond	Years after stocking §							
	1	2	3	4	5	6	7	8
Missouri strain								
Hammond	0.06	0.5	2.0	4.7	5.4	5.8	...	...
Hillendale	0.02	0.1	...	...	...	...	...	...
Washburn	0.13	0.4	1.0	1.5	2.0	3.7	...	...
Swanson	‡	0.2	0.7	...	...	...	...	...
Oneida Lake strain								
Swanson	0.09	0.4	0.9	1.3	2.2	3.2	5.2	6.0
Johnson	0.18	0.8	...	...	...	...	...	...
North Shannon	0.04	0.2	0.4	...	...	...	...	...
South Cronk	0.13	0.4	0.9	1.3	2.0	3.4	5.4	...
Frost †	5.0	5.6	5.4	6.0	...	...	...	...

* In all but Frost pond the fish stocked were fingerlings; those of both strains averaged 0.005 pound.

§ Data in pounds. In project ponds 0.5-pound catfish averaged about 10.5 inches in total length, 2-pound fish about 17 inches, and 5-pound fish about 23 inches.

† Catfish stocked in Frost pond were adults; they averaged 4.7 pounds.

‡ No data available.

time of inventory during years after stocking. They are grouped by strain of catfish. The author considers differences in the indicated growth rates between Missouri catfish and Oneida Lake stock to be non-significant. Variability within years in both groups of ponds was quite high.

What factors influenced growth rates of catfish stocked as fingerlings? Pond fertility and population density are two obvious ones, however data on both of these are not very reliable for reasons already given. South Cronk and Washburn were probably the most fertile ponds, and in both the population density was judged to be quite high while growth was quite slow. In the Washburn pond growth of the sole survivor of the original stock was good after a severe summerkill in Year 5. Population density was lowest in the moderately fertile Hammond pond in which growth was most rapid. The data suggest that growth rates varied inversely with population density, but the evidence is clearly not conclusive.

Davis (1959) considered 0.5-pound channel catfish as of "desirable size" in Kansas; Swingle (1950) considered 0.5 pound to be the minimum harvestable size, but he has subsequently changed it to 0.3 pound[4]. If minimum harvestable size in New York is considered to be 0.5 pound, then the original catfish stock usually attained harvestable size at age II+ or III+. Some catfish attained harvestable size at II+ in five of the eight ponds where the original stock survived to this age.

The largest catfish taken in project ponds came from the Hammond pond in Year 7, i.e., after it had completed eight seasons of growth. It was not weighed, but was judged to weigh about 12 pounds.

Data on the mean weight, near the end of successive growing seasons, of catfish hatched in project ponds are given in Table 6. These data

Table 6. Mean Weights of Catfish in Designated Year Classes Near the End of Successive Growing Seasons

Pond	Year class	Growing season *		
		First	Second	Third
Hamond	1958	0.003	0.19	0.56
Hammond	1959	0.01	0.05	....
Washburn	1957	0.003	0.05	0.57
South Cronk	1960	0.003	....	....
Frost	1957	0.005	0.05	0.15
Frost	1958	0.001	0.03	....

* Data in pounds.

were collected in late summer or autumn. The ranges in growth rates were quite similar to those observed for the original catfish stock (Table 5).

[4] Swingle, H. S., personal communication, 1960.

REPRODUCTION

Table 7 contains information on ages, sizes and standing crops of the original stock in years when successful reproduction occurred. What factors limited reproductive success of the catfish?

Krumholz (1950) reported that spawning facilities such as nail kegs could be placed in a catfish pond if reproduction was desired. Project personnel placed a spawning box (size unknown) in the Frost pond in the spring of 1956 and another in the DeGraff pond in the spring of 1957. Also in the spring of 1957, a number of suitably anchored nail kegs were placed in each of the ponds still under study at that time. One or more of these kegs remained intact in each pond for at least 3 years. A truck tire was placed in the Swanson pond in the spring of 1958. Spawning facilities were therefore available; whether the catfish used them could not be determined.

Catfish spawned successfully in four of the five ponds under study after 1956. Reproduction occurred in two successive years in two ponds.

TABLE 7. SUMMARY OF DATA ON CATFISH POPULATIONS OF ORIGINAL STOCK FOR YEARS IN WHICH THEY SPAWNED, BASED ON INVENTORIES MADE SEVERAL MONTHS AFTER SPAWNING OCCURRED *

Pond	Year of spawning	Catfish population				
		Age	Weight (pounds)		Standing crop (pounds)	
			Mean	Maximum	Total	Per acre
Missouri strain						
Washburn§	1957	IV+	1.5	2.5	65	260
Hammond†	1958	V+	5.4	8.0	90	180
	1959	VI+	5.8	9.3	100	200
Oneida Lake strain						
Frost§	1957	‡	5.6	9.2	65	95
	1958	‡	5.4	8.5	55	80
South Cronk†	1960	VIII+	>5.4	>6.0	‡	‡
Swanson *†	....	VIII+	6.0	7.7	35	120

* No reproduction occurred in Swanson pond; data for 1960 included for comparison. Remaining original stock all killed in March 1961.
§ Last reproduction check made in 1959; in Washburn pond almost all remaining original stock killed in July 1958.
† Last reproduction check made in 1960.
‡ No data available.

Catfish of the three stocks that survived for at least 2 years after stocking (Oneida Lake fingerlings of 1952, Missouri fingerlings of 1953, and Oneida Lake adults of 1955) reproduced successfully in at least one pond; thus there was apparently no difference in this respect between strains.

The youngest age at which catfish first spawned successfully was IV+, in the Washburn pond. At that time the catfish in this pond ranged from 1.0 to 2.5 pounds. Perhaps these data approximate the minimum age and minimum size at which reproduction might be expected to occur in New York ponds. However, reproduction did not occur in other ponds until the catfish were either older or larger; some factor or factors must have delayed spawning in these other ponds. Population size does not seem to have been too small nor density too large to prevent earlier spawning. Thus the factors limiting reproductive success in the project ponds are not known.

Discussing catfish management in Kansas, Davis (1959) summarized the findings of a number of authors on age and size at first spawning thus:

> "Although some channel catfish become sexually mature in their second year, most spawn for the first time when they are three years old. If growth is slow four or five years are required to attain sexual maturity. Channel catfish usually are between 11 and 16 inches long when they spawn for the first time. Males become sexually mature at a slightly smaller size than females."

At 11 and 16 inches, catfish in project ponds weighed about 0.4 and 1.4 pounds, respectively.

Population estimates were not made for year classes spawned in the ponds. However, some measure of relative reproductive success is available from the numbers captured in seining. On the basis of these data the author concludes that, in four of the six ponds, between about 150 and 600 catfish hatched in the pond attained an age of I+. The 1958 year class in the Hammond pond was apparently quite small with about 40 catfish surviving to I+. The South Cronk pond was not inventoried the year following reproduction so that no data on survivors were obtained.

Standing Crops

Data on total standing crops (and harvests) are summarized in Table 8. All estimates greater than 10 pounds per acre have been rounded to units of 10. Greater precision is not justified in view of the possible inaccuracies in estimates of population size, mean weight and mean area of pond.

Total standing crops of catfish in the five ponds continued beyond Year 4 sooner or later exceeded 100 pounds per acre. This occurred earliest (Year 2) in the South Cronk and Washburn ponds where survival was highest. In the Washburn pond it reached 300 in Year 3 but fell abruptly in Year 5 as a result of a summerkill. Conditions in the Washburn pond at the time of this summerkill suggested lack of oxygen brought on by a heavy bloom, high turbidity caused by cattle, and warm still

TABLE 8. ESTIMATED STANDING CROPS AND HARVESTS OF CATFISH ACCORDING TO STRAIN ANNUALLY AFTER STOCKING*

Pond	Year 1		Year 2		Year 3		Year 4		Year 5		Year 6		Year 7		Year 8
	Crop	Harvest	Crop	Harvest	Crop	Harvest	Crop	Harvest	Crop	Harvest	Crop	Harvest	Crop	Harvest	crop
Missouri strain															
Hammond	>5	1	40	0	70	0	170	0	180	0	200	30	220	20	..
Hillendale	>1	1	>1	..	..	..	..	..	..	..	..	..	..	..	..
Washburn	40	1	120	0	300	50	280	120	40	0	40	..	..	..	..
Oneida Lake strain															
Johnson	5	0	20	5	..	..	..	..	..	..	..	..	..	..	..
North Shannon	10	0	30	5	40	..	..	..	..	..	..	..	..	..	..
South Cronk	30	0	100	5	170	0	110	20	110	0	150	50	>50	..	..
Swanson	10	0	70	30	90	10	90	10	90	0	110	20	140	30	120
Frost§	90	0	90	0	100	0	90	0	90	..	..	..	..	..	..

* Data in pounds per acre, rounded to units of 10 except when estimate was less than 10.
§ Adult fish stocked at rate of 90 pounds per acre.

days. The data suggest that carrying capacities of the project ponds varied from about 150 to 300 pounds per acre.

Harvests

All the harvest data (Table 8) are considered to be quite reliable with the exception of those for South Cronk pond. This pond was over a mile from human habitation and was visited by more local fishermen than reported their catches.

Most of the harvests were made by project personnel during inventories. Fish removed during Years 1 and 2 were taken for stomach analyses. Older fish were taken following seining at the request of cooperators or to test flavor, concerning which there was divergent opinion.

The owner of the Washburn pond caught 16 of the originally stocked catfish on set lines in Years 4 and 5. The owner of the Swanson pond captured four fish by bait casting in Year 4. An unknown number of catfish were removed from the South Cronk pond between Years 3 and 8. None was reported harvested at other times in the above ponds, or at any time in the remaining ponds. The owners of the Hammond and Frost ponds reported fishing their ponds during two years but failed to catch any of the original stock; some yearlings were caught in the Hammond pond in Year 7.

Optimum harvest models (see Regier, 1963a) were not constructed; survival rates and age at first spawning were considered too variable to justify the necessary generalization. However, from an examination of data in Table 8, the author concludes that thriving populations in fertile ponds could support harvests of 25 to 50 pounds per acre per year beginning about Year 4.

Population Condition

The terms "crowded" and "uncrowded" are used in this section in the same sense as by Regier (1963a). Data on the plumpness of catfish, as estimated by a method similar to that described for bass by Regier, are given in Table 9. However, these data are given for individual lots of the original stock as they aged and increased in size. The data for bass were given on a within-population basis, i.e., data on all year classes were lumped.

The method of deriving the "standard" plumpness for catfish needs further explanation. Carlander (1953) listed data on length-weight relationships of channel catfish from six waters in Iowa, Ohio, Oklahoma, and Virginia. The present author plotted these data on logarithmic paper and fitted a curve by eye to the points. The curve was slightly convex upwards with total length as the absissa and weight as the ordinate. Two curves were then drawn parallel to the first curve so that they en-

TABLE 9. MEAN WEIGHTS OF CATFISH OF CERTAIN YEAR CLASSES AT SPECIFIED LENGTHS ACCORDING TO STRAIN OF STOCK

Pond	Year class*	Total length (inches)§			
		10	15	20	25
Missouri strain					
Hammond	1953	0.40	1.4	3.8	6.0
	1957	0.28	0.8	...	...
Washburn	1953	0.37	1.2	2.6	...
	1957	0.33	...	...	...
Swanson	1953	0.37	...	...	...
Oneida Lake strain					
Swanson	1952	0.37	1.3	3.3	6.7
Johnson	1952	0.42	...	...	...
North Shannon	1952	0.33	...	...	...
South Cronk	1952	0.39	1.2	3.0	...
Frost	?	....	...	3.1	6.4
	1957	0.30	...	...	...
Mixed					
Standard†	mixed	0.23–0.29	0.9–1.1	2.0–2.7	5.6–7.4

* The 1952 and 1953 year classes were original stock; the others were spawned in pond.
§ Data in pounds.
† From Carlander (1953), see text.

closed about 90 per cent of the plotted points. The limits of the ranges given for the standard in Table 9 correspond to these two lines.

Data in Table 9 indicate that catfish in project ponds were generally more plump than the standard catfish. At 10 and 15 inches, weights of originally stocked fish were all above the range given by Carlander (1953), but when these fish had attained lengths of 25 inches their weights fell within the range.

Data on plumpness are given for one year class spawned in each of the Hammond and Washburn ponds. Catfish progeny in these two cases were less plump than their progenitors had been at comparable ages.

Catfish in the Washburn pond grew relatively slowly during the third and fourth years following stocking. Standing crops during this period ranged from 250 to 300 pounds per acre. In spite of the high density

and low growth rate, plumpness remained above the standard. Apparently, catfish were not seriously crowded in any of the project ponds during the period of study.

Some information is available on the food of catfish in project ponds. The data indicate that the fish were relatively unselective carnivores since insects, tadpoles, frogs, newts and fish were found in stomachs. Perhaps the ability to utilize a great diversity of forage organisms available, because of "edge effect", explains why their plumpness remained good even when standing crops in moderately fertile ponds surpassed 200 pounds per acre.

Pond-owner Reactions

Four of the five ponds that were studied for 5 or more years were owned by private cooperators. Three of the four cooperators were dissatisfied because the catfish usually failed to take bait or lures offered them. One found the flavor of his catfish disagreeable; another considered it "strong". Project personnel sampled catfish from three ponds and found them palatable, though not exceptional.

DISCUSSION AND CONCLUSIONS

Channel catfish have been widely recommended for pond stocking in states south and west of New York. But apparently no serious studies have been made of the ecology of this species in farm ponds. Brown (1951) referred to studies in Texas, and Davis (1959) to studies in Kansas, but both of these were of even more limited scope, at least with respect to farm ponds, than the present project. Swingle (1959) reported on experiments to develop methods of commercially producing channel catfish in ponds by supplemental feeding. His findings do not, therefore, have direct relevance to catfish in ordinary farm ponds.

Channel catfish do not appear to hold much promise for farm ponds in New York for the following reasons.

1. Channel catfish are difficult to produce cheaply in large numbers for stocking purposes (Clemens and Sneed, 1957; Swingle, 1959; see also Geibel and Murray, 1961).
2. Survival of stocked fingerlings was found to be low for most project introductions.
3. Occurrence of successful reproduction was very spotty.
4. In some ponds the growth rates and standing crops were satisfactory when compared with bass-bluegill or bass-shiner populations. However, the unpredictability of survival and of reproduction implies that harvest quotas would be unpredictable.

The author believes that government agencies should not at present provide catfish stock to New York pond owners. Some pond owners might consider the risk of unpredictable survival and reproduction worth

the chance of getting large catfish in their ponds. Apparently, the only management that channel catfish require in well built, carefully managed ponds is provision of spawning sites. Nail kegs, tiles, milk cans or truck tires, all partly buried in the pond bottom, are apparently satisfactory spawning sites.

Channel catfish have been recommended as a third species in combination with bass and bluegills. Lagler (1952) listed two recommended formulae. The present author sees no objection to adding catfish at rates of perhaps 50 fingerlings per acre to bass-bluegill or bass-shiner ponds in New York. But few pond owners in this State would be likely to go to the necessary bother and expense of acquiring catfish stock for this purpose.

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EFFECTIVENESS OF ARCHERY IN CONTROLLING DEER ABUNDANCE ON THE HOWLAND ISLAND GAME MANAGEMENT AREA[1]

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ABSTRACT

By 1950 deer on the 3.78-square mile Howland Island Game Management Area had become numerous enough to require reduction and control. Various open seasons, both for gunners and for archers, were held. Gunning was the most effective, especially for reducing the initial overpopulation. However, it was found that archery for deer of either sex was reasonably effective in controlling the population after it had been reduced to a satisfactory level. Results indicate that, in an island situation such as the one studied, a satisfactory deer harvest can be achieved by archers if there are between 100 and 200 per square mile per day and at least half of them are active enough to keep deer on the move.

Deer have been resident on the Howland Island Game Management Area for more than 20 years. By 1950 the population began to exceed the carrying capacity of the range and a reduction in numbers was needed. Because of the island situation, hunting could be controlled and the number of deer removed could be counted. Thus, data could be obtained on hunter success, the degree of population reduction in relation to hunting pressure and the number of deer killed but not recovered by the hunters. There was also an opportunity to compare the effectiveness of archery with that of gunning as a means of population control.

Howland Island is formed by a great bend of the Seneca River, in Cayuga County about 7 miles north of Cayuga Lake, across the base of which it is separated from the mainland by secondary channels of the river and the Barge Canal. The surrounding waters have a minimum width of about 150 feet but average about 200 feet wide.

At the time of this study the game management area comprised 3,127 acres or 4.89 square miles. The relative proportions of cover types and related features are shown in Table 1. Of the total 2,418 acres (3.78 square miles) of dry land, 124 acres used for game farm purposes were posted as refuge and 2,294 acres (3.58 square miles) constituted the deer hunting area. As noted in the table, the 413 acres of marsh were also essentially a refuge with respect to deer hunting.

In 1950, 1952, 1955, 1956 and 1957 deer hunting on the area was permitted during November by daily permit. Regulations as to number of days, type of hunting, and sex of deer that might be taken[2] varied

[1] A contribution of Federal Aid in Fish and Wildlife Restoration Project W-89-R. All records of deer taken and permits issued were furnished by personnel of the North Central Game Management District.

[2] Throughout this paper "buck" means a deer with antlers 3 inches or more in length.

TABLE 1. RELATIVE PROPORTIONS OF COVER TYPES AND RELATED FEATURES ON HOWLAND ISLAND GAME MANAGEMENT AREA AND AMOUNT OPEN TO DEER HUNTING

Cover type or feature	Area in acres*	
	Total	Open to deer hunting
Open water	296	...
Marsh (mostly along river edge)	413	†
Cultivated (including hay in rotation)	389	363
Slightly overgrown fields	195	186
Brush	470	428
Woodland	1,339	1,305
Buildings and work area	25§	12
Total	3,127	2,294

* Determined from aerial photograph.
§ Includes about 13 acres of service roads.
† Although technically open to hunting, the 413 acres of marsh were seldom penetrated by deer hunters.

TABLE 2. DEER HUNTING REGULATIONS ON HOWLAND ISLAND GAME MANAGEMENT AREA

Year	Gunning		Archery	
	Bucks only	Any deer	Bucks only	Any deer
	Number of days hunting permitted			
1950	5	1	..	..
1952	4	2	..	14
1955	..	1	..	1
1956	..	..	5	1
1957	..	..	..	3
Total	9	4	5	19
	Number of daily permits issued			
1950	873	971	..	..
1952	750	500	..	1,017
1955	..	222	..	434
1956	..	..	1,213	471
1957	..	..	..	1,715
Total	1,623	1,693	1,213	3,637

(Table 2). Since hunters were required to pass a permit station both on entering and on leaving the area, an accurate tally of their numbers

Table 3. Hunter Success on the Howland Island Game Management Area

Hunting permitted for	Daily permits issued	Deer taken	Days per deer taken
Gunners			
Bucks only	1,623	133*	12.2
Any deer	1,693	531*	3.2
Archers			
Bucks only	1,213	9	134.8
Any deer	3,637	189	19.2

* These figures do not include 15 deer taken in 1950 for which data are incomplete (see Table 4).

and of the deer taken was possible. Hunter success is summarized in Table 3. Records of other deer losses were obtained through field surveys by Department personnel.

DATA RECORDED

During the five years, known losses from all causes totaled 954 deer (Table 4). This represented 50.5 deer per square mile per year from the total dry land area and 53.3 deer per square mile per year from the hunted area. The corresponding rates for adult males were 10.8 and 11.4, respectively. Although no records were obtained, it is estimated that 10 to 15 deer may have been lost from various causes during each of the intervening years when no hunting was done. More deer were taken by hunting the first year than in any subsequent year.

An unusual feature in 1950, when only gunning was permitted, was that 101 adult males were taken during the five days of buck-only hunting, while none was taken on the sixth day when any deer could be killed. On this last day, however, several bucks were seen in the refuge area, and 258 antlerless deer were taken.

In 1952, when gunning was permitted for six days, 32 adult males were taken during the four days of buck-only hunting, while during the two days any deer could be shot six adult males and 120 antlerless deer were taken. Similarly in 1956, when hunting was limited to archery, nine adult males were taken during the five days of buck-only hunting, while during one day of hunting for deer of either sex two adult males and 23 antlerless deer were taken.

The frequency of deer that are wounded but not recovered is important to game managers. On this area during the five years, gunners legally took 679 deer and 27, or 3.98 per 100, others that had been wounded were found later. For archers the figures were 198 and 14, or 7.07 per 100.

TABLE 4. KNOWN LOSSES OF DEER FROM ALL CAUSES ON THE HOWLAND ISLAND GAME MANAGEMENT AREA DURING YEARS HUNTING WAS PERMITTED

Year	Male		Female		Age and sex unknown	Total
	Fawn	Adult	Fawn	Adult		
Legal gunning						
1950	64	101	66	128	15*	374
1952	33	38	26	61	...	158
1955	30	23	42	52	...	147
Total	127	162	134	241	15	679
Legal archery						
1952	1	4	...	6	...	11
1955	18	17	15	21	...	71
1956	7	11	7	8	1	34
1957	25	10	21	22	4	82
Total	51	42	43	57	5	198
Illegal gunning						
1950	...	...	...	...	9	9
1952	1	...	...	...	1	2
1957	...	...	...	...	4	4
Total	1	...	...	...	14	15
Gunshot wounds						
1950	...	...	...	...	15	15
1952	...	...	...	1	6	7
1955	...	...	...	...	5	5
Total	...	...	...	1	26	27
Arrow wounds						
1952	...	...	...	...	3	3
1955	...	...	...	...	2	2
1956	...	...	...	...	5	5
1957	...	...	...	...	4	4
Total	...	...	...	...	14	14
Dogs and unknown causes						
1952	...	...	...	...	1	1
1955	...	...	...	...	7	7
1956	...	...	...	...	9	9
1957	...	...	...	...	4	4
Total	...	...	...	...	21	21
All causes						
1950	64	101	66	128	39	398
1952	35	42	26	68	11	182
1955	48	40	57	73	14	232
1956	7	11	7	8	15	48
1957	25	10	21	22	16	94
Total	179	204	177	299	95	954

* Estimated number taken by hunters entering and leaving area by boat.

Also, deer taken illegally during the open season are of interest. None was attributeable to archers, but gunners killed 15. If these are added to those that were wounded but not recovered, gunning resulted in associated losses of 6.19 deer for each 100 legally taken.

DISCUSSION

In 1950, prior to the first open season, the deer population on the Howland Island Game Management Area must have been at least 500 because 398 were known to have been removed and the number present after the season was estimated at more than 100. Estimates were not made in subsequent years, but in the fall of 1958 it was possible to count 80 deer while walking or driving about the Island and the total population was probably about 150. Hunting had reduced deer abundance, but the density was still high.

Some insight into the nature of the deer population on Howland

TABLE 5. COMPARATIVE LEGAL TAKE OF DEER ON THE HOWLAND ISLAND GAME MANAGEMENT AREA AND IN ADJOINING TOWNS IN 1955

Town	Area in square miles	Deer taken					
		Male		Female		Total	Per square mile
		Fawn	Adult	Fawn	Adult		
Howland Island Game Management Area							
Conquest.....	3.78	48	40	57	73	218	57.7
Adjoining towns in Cayuga County							
Brutus.....	22.6	2	7	1	4	14	0.6
Cato.....	34.6	2	8	1	3	14	0.4
Conquest*.....	31.2	10	20	15	40	85	2.7
Ira.....	34.5	2	4	....	....	6	0.2
Mentz.....	17.1	5	7	7	13	32	1.9
Montezuma....	19.0	4	13	4	11	32	1.7
Victory.....	34.4	4	2	2	2	10	0.3
Total.....	193.4	29	61	30	73	193	1.0
Adjoining towns in Seneca and Wayne Counties§							
Tyre.....	33.4	....	13	....	....	13	0.4
Butler.....	36.6	....	3	....	....	3	0.1
Savannah.....	35.8	....	39	....	....	39	1.1
Total.....	105.8	....	55	....	....	55	0.5

* Except Howland Island Game Management Area.
§ Hunting permitted for bucks only.

Island is afforded by data for the surrounding area. The number of deer taken in the remainder of the town of Conquest (outside the game management area) and in adjoining towns has consistently been low (Table 5). For example, in 1955 when the legal harvest on the Island was 218 or 57.7 per square mile, that elsewhere in the same town was 85 or 2.7 per square mile. When the adjoining towns in Cayuga County, where hunting regulations were similar, are combined, the take was 193 or 1.0 per square mile.

There had been no deer hunting in 1953 and 1954 on the Island, but it had been permitted in the remainder of the town of Conquest. Thus the harvest in 1955 might be considered to represent an average of 19.2 per square mile per year which still reflects a high density. It seems clear that the Howland Island Game Management Area constituted a refuge for deer and a focal point of deer population growth in the town of Conquest.

In Seneca and Wayne Counties in 1955 deer hunting during the regular season was restricted to gunning for bucks. The take in the town of Savannah, which has a common boundary with the game management area, was greater than the number of bucks taken in any of the other towns listed in Table 5 including Conquest outside the Island. Here, also, it would seem that the Island had acted as a reservoir of deer for part of the town of Savannah.

In Table 6 rates of deer harvest by gunning and by archery at different levels of hunting pressure on the Howland Island area are compared. It is evident that gunning was the more effective method.

TABLE 6. COMPARATIVE RATES OF DEER HARVEST BY GUNNING AND BY ARCHERY AT DIFFERENT LEVELS OF HUNTING PRESSURE IN THE HOWLAND ISLAND GAME MANAGEMENT AREA

Year	Days of hunting	Hunter days*	Deer taken	Deer per 100 hunter days	Hunters per square mile per day§
		Gunning			
1950	6	1,844	374	20	86
1952	6	1,250	158	13	58
1955	1	222	147	66	62
		Archery			
1952	14	1,017	11	1	20
1955	1	434	71	16	121
1956	6	1,684	34	2	78
1957	3	1,715	82	5	160

* Equivalent to number of permits issued (see Table 3).
§ In terms of hunted area of 3.58 square miles.

Only in 1955 did the rate for archery reach the range of those recorded for gunning. Nevertheless, archery seemed promising as a means of managing the deer population.

Consequently archery seasons for deer of either sex were held on the Island in the years 1958 through 1962. Such hunting was permitted on the two Saturdays immediately before the gunning season during the first four years and on one Sunday in 1962. It was hoped that this would result in enough deer being killed and enough others being driven to the mainland to prevent or slow a population increase. Fall numbers were estimated at 100 and 150 deer, and the recorded take was 29, 33, 31, 20 and 37 for the five years, respectively. Negligible numbers of bucks were taken during the following gunning seasons each year. About 70 deer were estimated to have been on the area in March of 1961, and

Table 7. Rate of Deer Harvest in Relation to Hunter Concentration on the Howland Island Game Management Area when Hunting Permitted for Deer of Either Sex by Archery Only

Year	Days of hunting	Hunter days*	Hunters per square mile per day§	Deer taken	
				Number	Per 100 hunter days
1952	14	1,017	20	11	1
1955	1	434	121	71	16
1956	1	471	132	25	5
1957†	1	1,075	300	79	7
1958	2	1,180	165	29	2
1959	2	1,480	207	33	2
1960	2	1,190	166	31	3
1961	2	917	128	20	2
1962	1	651	182	37	6

* Equivalent to number of permits issued.
§ In terms of hunted area of 3.58 square miles.
† Figures given for November 9 only; hunting also permitted on November 15 and December 3, but the archers did little moving and 400 took only one deer and 240 took two deer on these dates, respectively.

about 150[3] in March of 1963. This hunting is considered to have been reasonably effective in controlling the deer population, discounting the influx during the unusually severe winter of 1962–63.

The data for archery also show that the degree of concentration of hunters was directly related to the rate of harvest. This is best illustrated by the records for occasions when hunting for deer of either sex was

[3] It seems likely that the number present in March of 1963 would have been somewhat higher than that in 1961 because fewer deer than should have been were taken by hunters the previous fall. But the population on the Island was increased substantially as a result of the unusually severe winter of 1962–63. The river was frozen for 3 months and many deer sought refuge on the Island, especially to escape dogs which ran them from as far as 5 miles away.

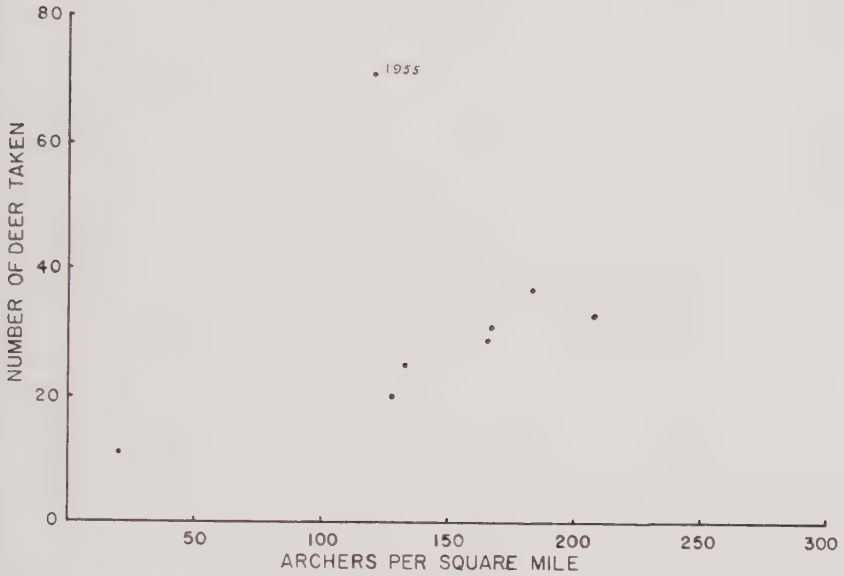

Figure 1. Number of deer taken in relation to the concentration of archers hunting on the Howland Island Game Management Area.

permitted (Table ~ and Figure 1). The unusually high rate for 1955 probably reflects a high deer population density after two years in which they were not hunted on the Island. Average success during the last seven years was about one quarter that for 1955 because the deer population was correspondingly small.

Concentrations of one archer for each 3 to 6 acres of land can be hazardous. Nevertheless, such concentrations existed on the Howland Island area in at least eight years and only one accident occurred. This involved a hunter who was hit by a ricochetting arrow in 1957 when the concentration of archers was greatest.

It would, therefore, appear that under conditions such as those on Howland Island a satisfactory deer harvest can be achieved by archers if there are between 100 and 200 per square mile per day and at least half of them are active enough to keep deer on the move. On the other hand, even though deer may be abundant, if archers are scattered or not active enough to keep deer moving, few deer will be taken. Similar effectiveness would not be expected, however, on a mainland area.

AGE AND GROWTH OF WHITE BASS IN ONEIDA LAKE, NEW YORK[1]

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ABSTRACT

Age and growth determinations were made from scales of 628 white bass collected from 1956 through 1961. During these years the 1954 year class comprised 85 per cent of the catch in experimental gill nets. Mean calculated total lengths of white bass were 5.3, 10.3, 12.3, 13.3 and 14.0 inches for ages I through V. Fish and aquatic insects were the food items most frequently found in the stomachs of white bass during summer.

White bass (*Roccus chrysops*) were collected during an investigation of the sport fishery of Oneida Lake, New York. This species is of minor importance in the angling catch since most fishing effort is for walleyes (*Stizostedion vitreum*) and yellow perch (*Perca flavescens*). But, white bass probably have considerable effect on the ecology of the lake in years of high population density. During 1956 and 1957 white bass were abundant in Oneida Lake, but they had declined to a low level by 1961. This paper describes the age, growth and food of white bass collected from 1956 to 1961.

Oneida Lake is approximately 20 miles long and 5 miles wide with an area of 50,000 acres. Maximum depth is 55 feet with a mean depth of 25 feet. There is no permanent thermal stratification in summer. Fertility is moderately high and blooms of blue-green algae are common in summer.

PROCEDURE

Scales and measurements were obtained from 628 yearling and older white bass collected from 1956 through 1961. Of these, 338 were taken in nylon gill nets containing 100 feet of 2-, 2½-, 3-, 3½- and 4-inch mesh and set overnight at the same 15 sites each year. Additional scale samples were taken from 220 white bass caught in trap nets and from 70 collected by shocking, trawling and angling. Trapnetting and shocking were conducted in spring and fall while gill net, trawl and angling samples were collected in summer.

Growth of young (age 0+) is based on measurements of 810 white bass collected in July through October 1956–1961. Young white bass in 1956–1958 were netted in ¼-inch-bar-mesh haul seines. In later years most young were taken in small bottom and midwater otter trawls with ¼-inch mesh in the cod end.

[1] Data were collected as a part of Federal Aid in Fish and Wildlife Restoration Project F-17-R. The authors are indebted to Dr. A. W. Eipper for review and comment on the manuscript.

All fish except young were measured fresh and their total lengths were recorded to the nearest 0.1 inch. Young white bass were measured after preservation in 10 per cent formalin. All scale samples were taken at the tip of the left pectoral fin below the lateral line. Plastic impressions of the scales were made and these were examined on a scale projector. Stomach contents were examined and the occurrence of food items recorded in the field.

AGE AND GROWTH

The 1954 year class constituted 85 per cent of the total gill net catch from 1956 through 1961 (Table 1) and was predominant in each of these

TABLE 1. AGE DISTRIBUTION OF 338 WHITE BASS TAKEN IN GILL NETS IN ONEIDA LAKE, 1956–1961

Year	Age group						
	I	II	III	IV	V	VI	VII
1956	..	38	4	2	3	..	..
1957	1	..	94	3	3	..	..
1958	..	..	..	13	2	1	..
1959	..	..	..	12	97	7	3
1960	3	..	..	..	2	39	3
1961	..	..	..	..	..	2	6
Total	4	38	98	30	107	49	12

years. The 1955 year class and year classes prior to 1954 contributed most of the remaining catch. Only four fish (1 per cent of the gill net catch) were from year classes hatched after 1955. Fluctuations in year class abundance of white bass have been observed in other lakes (Howell, 1945; Sigler, 1949; Van Oosten, 1942) and seem to be characteristic of this species.

Lengths of white bass at each annulus were calculated from a body-scale relationship based on 702 fish including 74 young of the year. Data were grouped into suitable length-class intervals, and a regression table of total length on magnified scale image was made by a method described by Goulden (1952). Tests of significance for linear regression and deviations from linearity were made for the body-scale relationship. Deviations from linearity were significant at the 5 per cent level, indicating a curvilinear relation between body and scale lengths. To accommodate

Table 2. Mean Calculated Total Lengths (Inches) at Each Annulus for the 1948 to 1960 Year Classes of White Bass in Oneida Lake

Year class	Number of specimens, by age group *	Length at each annulus								
		1	2	3	4	5	6	7	8	9
1948	0, 0, 0, 0, 0, 0, 0, 1	4.8	7.4	10.5	12.4	13.1	13.7	14.2	14.9	....
1949	0, 0, 0, 0, 0, 0, 1	7.4	10.7	12.7	13.5	14.0	15.0	15.7	....	....
1950	0, 0, 0, 0, 0, 2	5.4	11.0	13.0	13.8	15.0	15.8	....	....	....
1951	0, 0, 0, 0, 10, 5	5.8	10.5	12.6	13.9	14.8	15.5	....	....	....
1952	0, 0, 0, 17, 8, 4, 3, 1, 1	6.2	10.6	12.6	14.1	15.1	15.5	15.8	17.0	17.4
1953	0, 0, 16, 6, 6, 6, 17, 6	6.1	10.4	13.5	13.9	14.8	15.4	15.9	15.8	....
1954	0, 82, 118, 15, 97, 82, 22	5.1	10.3	12.1	13.2	13.8	14.5	14.8	....	....
1955	1, 2, 0, 11, 38, 6	5.1	10.3	12.2	13.2	13.9	14.0	....	....	....
1956	0, 0, 0, 11, 1	5.0	9.0	10.6	11.6	13.4	....	....	....	....
1957	0, 0, 1, 1	4.9	10.1	12.0	12.8	....	....	....	....	....
1958	0, 3	5.5	8.6	....	....	....	....	....	....	....
1959	25, 1	5.8	10.8	....	....	....	....	....	....	....
1960	1	5.0	....	....	....	....	....	....	....	....
Weighted mean		5.3	10.3	12.3	13.3	14.0	14.7	15.4	16.0	17.4
Number of fish		628	601	513	378	317	157	52	9	1
Male		5.1	10.2	11.9	12.9	13.4	13.9	14.7	14.9	....
Number of fish §		197	192	177	124	104	35	10	1	....
Female		5.2	10.4	12.7	13.5	14.2	14.6	15.3	....	....
Number of fish §		187	187	156	113	99	38	6	....	....

* For example the 1951 year class was represented by 10 age V and 5 age VI white bass.

§ Sex was not determined for some fish which were aged.

for the curvilinear relationship, body-lengths were averaged for each 5-millimeter interval of magnified scale radius. A three-point running average of these points was then plotted and a line drawn through the points by eye. Lengths were back-calculated using a body-scale rule constructed in the manner described by Hile (1950). Weese (1951) reported a curvilinear body-scale relation for white bass in Texoma Reser-

voir, but in other studies the body-scale relationship has been adequately described by a straight line (Sigler, 1949; Van Oosten, 1942).

Weighted mean calculated total lengths of white bass were 5.3, 10.3, 12.3, 13.3 and 14.0 inches for ages I through V, respectively, based on the combined catch in all types of gear (Table 2). Calculated lengths of white bass caught in gill nets generally averaged lower at each annulus than lengths calculated from fish caught in other gear. For example, calculated lengths of fish in the 1954 year class taken by gill nets were 0.4 to 0.8 inches less at age IV to VII than lengths of the same year class back-calculated from fish taken by shocking, trapnetting and angling (Table 3). These differences suggest that a growth rate based on samples taken in some types of gear may not be representative of the growth rate

TABLE 3. MEAN CALCULATED LENGTHS OF THE 1954 YEAR CLASS OF WHITE BASS TAKEN IN GILLNETS AND CALCULATED LENGTHS OF THE 1954 YEAR CLASS TAKEN IN OTHER EXPERIMENTAL GEAR *

Gear	Annulus						
	1	2	3	4	5	6	7
Gillnet	5.0 (297)	10.2 (297)	12.0 (252)	13.0 (162)	13.6 (149)	14.1 (52)	14.5 (6)
Trapnet, angling and shocker	5.1 (119)	10.4 (119)	12.3 (82)	13.7 (54)	14.2 (52)	14.9 (52)	14.9 (16)

* Numbers of specimens in parentheses.

of the population. Since samples were collected by four types of gear the estimated growth rate based on the combined catch (Table 2) may not be seriously biased by gear selectivity.

Growth rate of white bass in Oneida Lake is about average when compared to that reported for other lakes (Carlander, 1953). Growth of the 1951, 1952 and 1953 year classes was slightly more rapid than growth of later year classes. The reduced growth rate following 1953 may reflect increased intraspecific competition caused by the exceptionally large 1954 year class.

Growth of females was more rapid than growth of males. Mean calculated lengths of females exceeded the calculated lengths of males by 0.6 to 0.8 inches at the third to seventh annuli (Table 2).

Mean lengths of young taken between August 15 and 31 ranged from a low of 1.9 inches in 1958 to 3.2 inches in 1959 (Table 4). Growth of young continued into October when sampling was terminated. Young white bass taken in late October of 1959 averaged 5.8 inches which is identical with the estimated length at the first annulus back-calculated from I+ and II+ fish taken in 1960 and 1961.

TABLE 4. MEAN TOTAL LENGTHS IN INCHES OF YOUNG (AGE 0+) WHITE BASS TAKEN IN SEINES AND TRAWLS IN ONEIDA LAKE, 1956–1961 *

Year	July		August		September		October	
	1–14	15–31	1–14	15–31	1–14	15–30	1–14	15–31
1956	0.9	1.4	1.8	2.3	3.0	...	...	...
	(1)	(26)	(14)	(8)	(50)	...	...	...
1957	...	1.4	...	2.7	3.2	3.1	...	...
	...	(1)	...	(2)	(39)	(9)	...	...
1958	...	...	1.7	1.9	2.7	3.2	3.5	...
	...	...	(10)	(23)	(3)	(55)	(6)	...
1959	...	...	...	3.2	...	4.2	...	5.8
	...	...	...	(85)	...	(3)	...	(21)
1960	...	...	...	3.1	3.5	3.9	...	...
	...	...	...	(55)	(129)	(66)	...	...
1961	...	1.5	1.9	2.6	3.4	3.7	...	4.4
	...	(10)	(79)	(12)	(45)	(55)	...	(3)

* Number of specimens in parentheses.

TABLE 5. FREQUENCY OF OCCURRENCE OF VARIOUS FOOD ORGANISMS IN STOMACHS OF AGE I AND OLDER WHITE BASS FROM ONEIDA LAKE, 1956–1961

Food item	Month					Total
	May	June	July	Aug.	Sept.	
Fish						
Yellow perch	..	..	8	17	..	25
White perch	..	..	..	1	..	1
White bass	..	..	..	1	1	2
Walleye	..	..	1	..	..	1
Johnny darter	..	..	..	3	..	3
Unidentified	..	2	6	27	2	37
Insects						
Mayflies	3	8	25	15	..	51
Chironomids	..	..	5	37	1	43
Zooplankton	..	1	2	18	..	21
Crayfish	..	..	4	8	1	13
Amphipods	..	1	2	6	..	9
Number of stomachs examined	3	24	95	191	9	322
Number empty	0	16	53	89	4	162

FOOD

Stomach contents of 322 white bass age I and older were examined (Table 5). Fish and aquatic insects were the food items generally found in the stomachs during the summer. Most fish taken by white bass were young yellow perch. In all years yellow perch were also the most abundant species of young observed in seining and trawling.

Most of the mayflies eaten were adults and nymphs of *Hexagenia limbata* which emerges in late June and early July. Chironomids replaced mayflies in the diet during late summer. Zooplankton was not prominent in the diet of adult white bass in Oneida Lake although McNaught and Hasler (1961) found this was the principal food of white bass in Lake Mendota.

DISCUSSION

White bass hatched in 1954 were predominant in the catch from 1956 through 1961. During the summer of 1954 gizzard shad (*Dorosoma cepedianum*) was one of the most abundant forage fish in Oneida Lake although this species had not been reported from Oneida Lake prior to 1954 and it has been rare since then. A large population of gizzard shad might act as a buffer reducing predation on young white bass. Whether the occurrence of gizzard shad or other factors were responsible for the strong 1954 year class of white bass is purely speculative. However, it is interesting that several important species in Oneida Lake produced strong year classes in 1954. These include the walleye (Forney, 1962), yellow perch (Pease, 1961), white perch (Alsop and Forney, 1962) and smallmouth bass (Forney, 1961).

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MANAGEMENT IMPLICATIONS OF THE TREND AND DISTRIBUTION OF THE LEGAL DEER KILL IN THE ADIRONDACK REGION[1]

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ABSTRACT

Data for the distribution of the legal kill of deer by towns in the Adirondack counties for the years 1941, 1954 and 1957 afford a means of evaluating some of the factors limiting abundance. Population levels, as reflected by the number taken per square mile, were consistently lower in the peripheral section of the region than in the central section. Overbrowsing and chronic losses from starvation in the central section are evidence that the carrying capacity of the range has been reached and that sustained increases in abundance cannot be expected. Proper management calls for harvesting does and fawns as well as bucks, especially in the less accessible areas, and improving the winter range. In the peripheral section the range is in good condition generally and starvation is negligible. Substantial increases in abundance are possible if losses among does can be substantially reduced. Illegal hunting is considered to be the chief cause of these losses.

Deer abundance is generally lower in the peripheral section of the Adirondack region than in the central section. This has been true for a long time. Yet the deer range in the peripheral section could support a higher population, while in the central section the carrying capacity under present range conditions has to a large degree been reached. Data for the distribution of the legal kill by towns in the Adirondack counties (Figure 1) afford a means of evaluating some of the limiting factors involved.

The two sections of this region (peripheral and central) were designated and described by Cheatum and Severinghaus (1950). Concerning the peripheral section they stated: "This section of the Adirondack region is poorer deer range than that of southern New York. . . . Deer wintering areas are mostly few in number, small and generally understocked with deer so that little winter mortality has occurred, except in a few isolated winter areas, even during severe winters." And regarding the central section: "In general this is the poorest deer range in the State . . . It includes most of the known wintering areas where malnutrition and winter losses have been chronic." This relationship still exists.

Except for the war period (1942 1946), the number of bucks taken annually has been relatively stable for many years (Table 1).[2] The fluctuations that occurred were associated primarily with the severity of winter conditions. During periods when winters were moderate or

[1] A contribution of Federal Aid in Fish and Wildlife Restoration Project W-89-R.

[2] The figures in both Tables 1 and 2 were calculated from the reported take by methods developed to compensate for the number of legally taken deer that were not reported by hunters. A comprehensive record of the deer take throughout New York State was compiled by Severinghaus and Brown (1956).

Figure 1. Counties of the Adirondack region.

mild, for example the years 1948 to 1954, the population and the buck take increased. From time to time, however, severe winters caused heavy starvation losses of both fawns and adults and resulted in sharp declines in the abundance of deer and the number of bucks taken. Severe winters of this kind occurred in 1939–40, 1943–44, 1947–48, 1954–55, 1958–59 and 1959–60. A sharp decline in the buck take after such winters reflects not only direct mortality from starvation but also the fact that many yearling bucks, that as fawns survived the winter, failed to recuperate rapidly enough to produce antlers of legal length the following summer.

The distribution of the take by towns was first recorded for 1941; it was tabulated next for 1954 and again for 1957. The figures are given in Table 2. The records for 1941 were tabulated by towns for the principal Forest Preserve counties only. Therefore, only the total numbers of deer taken are available for that year for the other counties of the region, i.e., for Jefferson, Oneida, Oswego, Saratoga and Washington. For purposes of comparison with respect to the magnitude and distribution of the legal deer kill, the records for 1954 and 1957 are appropriate

TABLE 1. NUMBER OF BUCKS TAKEN IN THE ADIRONDACK REGION, 1935 TO 1962

Year	Number taken	Year	Number taken
1935	7,590	1949	8,149
1936	9,234	1950	8,191
1937	9,187	1951	8,560
1938	9,700	1952	8,790
1939	10,229	1953	9,799
1940	8,012	1954	12,176
1941	7,812	1955	10,264
1942	6,840	1956	9,575
1943	6,396	1957	10,733
1944	5,055	1958	10,199
1945	5,184	1959	8,526
1946	6,540	1960	8,615
1947	8,125	1961	8,531
1948	6,200	1962	9,089

because they represent the two highest harvests during the years after 1941.

The legal kill of deer in terms of density reflects the general level of deer abundance. The records for the various towns, converted to deer taken per square mile, are also given in Table 2. These values were mapped for each town. Figure 2 shows the distribution of the towns where the kill in 1941 was 0.5 or more per square mile of land area compared with that of the towns where it was less than that. Figure 3 makes the same comparison for the same towns in 1957 (that for 1954 was essentially similar). There was little change in distribution from 1941 to 1957.

Also shown on these maps is the line of demarcation between the peripheral and central sections of the region as defined by Cheatum and Severinghaus (1950). The close correspondence between this line and that separating the two groups of towns is striking.

In the central area, with minor exceptions, the population tended continually to reach or exceed the carrying capacity of the range. Winter losses from starvation were chronic and substantial, varying directly with the severity of the winter. This happened despite the annual take of bucks, plus limited harvests of antlerless deer in 1943 and 1954.[3] In other words, mortality from hunting, including any illegal hunting that occurred, was not sufficient to hold the deer population within the carrying capacity of the range. Thus, in this part of the region, the limiting factor under existing range conditions was winter starvation.

[3] In 1943 hunting for antlerless deer was permitted, under special license, throughout the Adirondack region for six days during the regular season; 4,978 were taken. In 1954 such hunting was permitted in two wilderness tracts during the entire regular season (Cheatum, 1954); 1,658 were taken. Negligible numbers of antlerless deer were also taken during special archery seasons from 1952 to 1956.

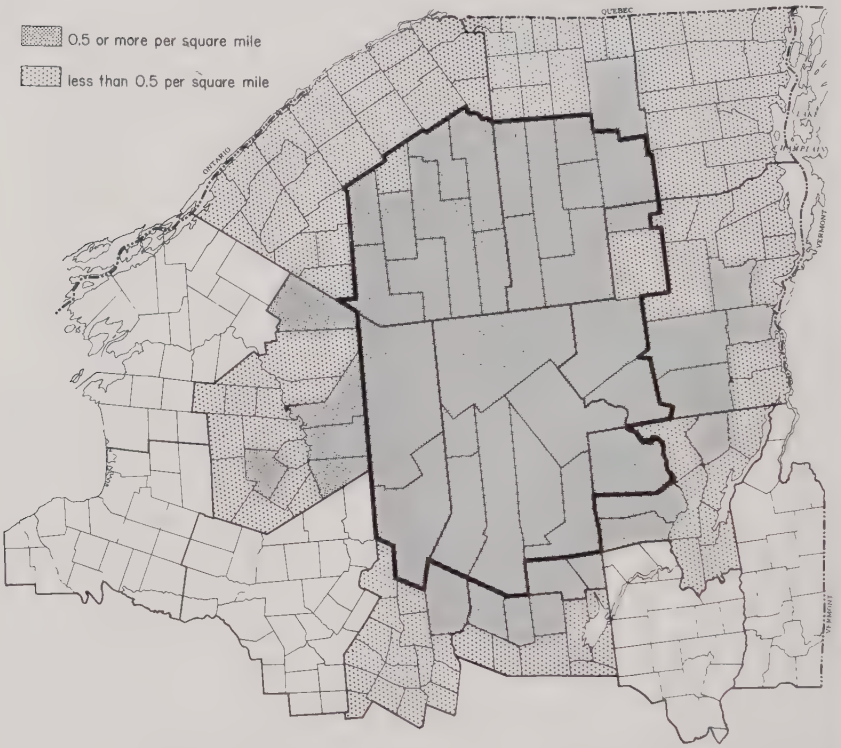

Figure 2. Distribution of towns in Clinton, Essex, Franklin, Fulton, Hamilton, Herkimer, Lewis, St. Lawrence and Warren Counties according to density of legal kill of bucks in 1941. Heavy line separates central and peripheral sections of Adirondack region (after Cheatum and Severinghaus, 1950).

In the peripheral area, on the other hand, the general level of deer abundance throughout the 16-year period remained low. Winter losses from starvation were negligible, indicating that the deer population was below the carrying capacity of the range. Furthermore, the legal take of deer, limited almost exclusively to bucks except in 1943, would not account for the lack of increase. Some other cause of mortality must have been responsible. Illegal hunting, especially the taking of does, is believed to have been that cause.

In general, 400 to 500 deer must be available for hunters to take about 45 bucks. In such a population the sex ratio among adults is about one buck to 1.4 does, with the adult does reproducing at a rate of about 1.5 fawns per doe. Nearly 80 per cent of the total annual loss is from illegal hunting, starvation, predation and miscellaneous causes, while only about 20 per cent is attributable to legal hunting. If the buck law were strictly observed and most other causes of loss greatly reduced, the deer population and the buck take would double every second to third year. Absence of such a rate of increase is evidence that

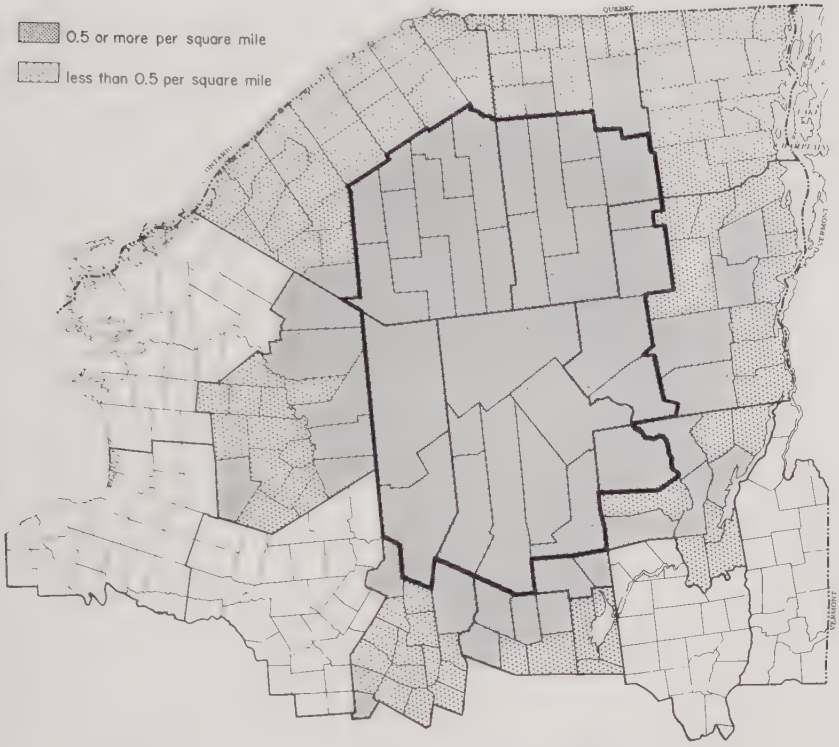

Figure 3. Distribution of towns in Clinton, Essex, Franklin, Fulton, Hamilton, Herkimer, Lewis, St. Lawrence and Warren Counties according to density of legal kill of bucks in 1957. Heavy line separates central and peripheral sections of Adirondack region (after Cheatum and Severinghaus, 1950).

losses of this magnitude from causes other than legal hunting are occurring.

Certain generalizations about the deer population of the Adirondack region may be stated.

1. In areas where starvation losses are low and the deer population is stable, losses from illegal hunting, predation and other causes must be relatively high.
2. In areas where starvation losses and predation losses are both low and the deer population is stable, losses from illegal hunting and other causes must be even higher.
3. In areas where starvation losses and losses from illegal hunting are high and the population is stable, open seasons for antlerless deer will substantially increase the number taken home by hunters without appreciably reducing the population the next year. This occurs because the waste of deer killed illegally or lost from starvation is reduced.
4. In areas where predation is high and the deer population is stable, other causes of mortality result in the death of about as many

TABLE 2. DISTRIBUTION BY TOWNS IN THE ADIRONDACK REGION FOR BUCKS TAKEN IN 1941, 1954 AND 1957

Section and town	Number taken			Number taken per square mile			Land area*
	1941	1954	1957	1941	1954	1957	
Clinton County							
Peripheral section							
Altona	32	41	28	0.3	0.4	0.3	102.4
Ausable	1	7	1	tr	0.2	tr	39.8
Beekmantown	1	5	0	tr	0.1	....	61.1
Black Brook	48	63	48	0.4	0.5	0.4	132.1
Champlain	1	0	3	tr	....	0.1	50.1
Chazy	6	5	19	0.1	0.1	0.3	55.1
Clinton	0	12	2	....	0.2	tr	68.1
Dannemora	21	10	6	0.3	0.2	0.1	61.1
Ellenburg	10	7	13	0.1	0.1	0.1	109.2
Mooers	0	1	4	....	tr	tr	89.4
Peru	4	5	9	0.1	0.1	0.1	79.4
Plattsburg	1	3	0	tr	0.1	....	48.0
Saranac	34	41	23	0.3	0.4	0.2	116.0
Schuyler Falls	0	4	0	....	0.1	....	37.8
Total	159	204	156	0.2	0.2	0.1	1,049.6
Essex County							
Central section							
Minerva	133	133	118	1.0	1.0	0.9	135.7
Newcomb	181	211	182	0.7	0.9	0.7	248.1
North Elba	64	92	78	0.4	0.6	0.5	151.4
St. Armand	38	46	35	0.7	0.8	0.6	57.4
Peripheral section							
Chesterfield	11	21	10	0.1	0.3	0.1	79.9
Crown Point	24	25	15	0.3	0.3	0.2	74.3
Elizabethtown	57	30	51	0.7	0.4	0.6	79.2
Essex	7	4	4	0.2	0.1	0.1	32.2
Jay	26	27	28	0.4	0.4	0.4	69.5
Keene	43	7	41	0.3	0.5	0.3	162.3
Lewis	33	46	50	0.4	0.5	0.6	85.6
Moriah	49	21	20	0.7	0.3	0.3	69.5
North Hudson	192	125	99	1.0	0.7	0.5	184.8
Schroon	72	88	119	0.5	0.6	0.9	136.5
Ticonderoga	23	26	32	0.3	0.3	0.4	81.6
Westport	6	9	24	0.1	0.1	0.4	60.6
Willsboro	8	13	9	0.2	0.3	0.2	42.8
Wilmington	21	26	16	0.3	0.4	0.2	66.3
Total	988	1,020	931	0.5	0.6	0.5	1,817.7
Franklin County							
Central section							
Altamont	181	347	271	1.5	2.9	2.3	119.5
Brighton	134	170	139	1.6	2.1	1.7	81.8
Duane	94	151	201	1.2	1.9	2.6	78.4

TABLE 2. (*continued*)

Section and town	Number taken			Number taken per square mile			Land area*
	1941	1954	1957	1941	1954	1957	
Central section (*cont'd.*)							
Franklin	158	159	141	0.9	0.9	0.8	175.6
Harrietstown	152	198	177	0.7	0.9	0.8	209.4
Santa Clara	213	344	315	1.2	1.9	1.8	180.0
Waverly	134	328	224	1.0	2.5	1.7	129.0
Peripheral section							
Bangor	0	31	0	....	0.7	....	43.5
Bellmont	120	110	105	0.7	0.7	0.6	168.0
Bombay	4	0	6	0.1	....	0.2	36.1
Brandon	12	40	32	0.3	1.0	0.8	41.9
Burke	0	0	0	....	....	....	45.3
Chateaugay	0	1	3	....	tr	0.1	49.7
Constable	0	0	0	....	....	....	33.8
Dickinson	3	15	18	0.1	0.3	0.4	46.0
Fort Covington	1	0	3	tr	....	0.1	36.1
Malone	20	32	22	0.2	0.3	0.2	101.8
Moira	1	8	9	tr	0.2	0.2	45.3
Westville	1	11	0	tr	0.3	....	35.6
Total	1,228	1,946	1,666	0.7	1.2	1.0	1,656.8
Fulton County							
Peripheral section							
Bleeker	32	30	28	0.5	0.5	0.5	58.6
Broadalbin	0	0	3	....	....	0.1	29.6
Caroga	23	27	28	0.5	0.5	0.6	50.7
Ephratah	4	21	13	0.1	0.5	0.3	40.5
Johnstown	9	7	3	0.1	0.1	tr	74.6
Mayfield	12	14	16	0.2	0.2	0.3	58.1
Northampton	5	7	6	0.3	0.4	0.3	18.5
Oppenheim	7	20	26	0.1	0.4	0.5	54.5
Perth	0	0	1	....	....	tr	26.6
Stratford	51	53	56	0.7	0.7	0.8	73.3
Total	143	179	180	0.3	0.4	0.4	485.0
Hamilton County							
Central section							
Arietta§	234	309	275	0.7	1.0	0.9	315.5
Indian Lake§	373	285	367	1.5	1.1	1.4	256.8
Inlet§	91	141	83	1.5	2.3	1.3	62.4
Lake Pleasant§	177	180	141	0.9	0.9	0.7	201.9
Long Lake§	410	737	518	1.0	1.8	1.2	415.9
Morehouse§	118	181	113	0.6	0.9	0.6	192.4
Wells	143	192	170	0.8	1.1	1.0	177.1
Peripheral section							
Benson	59	58	67	0.7	0.7	0.8	83.4
Hope	31	54	60	0.7	1.3	1.4	41.6
Total	1,636	2,137	1,794	0.9	1.2	1.0	1,747.0

TABLE 2. (*continued*)

Section and town	Number taken			Number taken per square mile			Land area*
	1941	1954	1957	1941	1954	1957	
Herkimer County							
Central section							
Ohio§	195	288	221	0.6	1.0	0.7	302.5
Webb§	506	896	583	0.9	1.9	1.3	466.1
Peripheral section							
Columbia	0	1	5	....	tr	0.1	36.0
Danube	0	11	10	....	0.4	0.3	29.6
Fairfield	1	5	10	tr	0.1	0.2	40.6
Frankfort	0	13	6	....	0.4	0.2	36.2
German Flats	0	7	7	....	0.2	0.2	31.3
Herkimer	3	4	3	0.1	0.1	0.1	30.2
Litchfield	0	4	1	....	0.1	tr	30.3
Little Falls	0	7	9	....	0.3	0.4	21.7
Manheim	1	1	1	tr	tr	tr	28.1
Newport	0	1	0	....	tr	....	32.2
Norway	7	11	12	0.2	0.3	0.3	36.0
Russia	16	33	31	0.3	0.6	0.5	56.8
Salisbury	56	58	93	0.5	0.5	0.8	114.1
Schuyler	0	4	3	....	0.1	0.1	42.0
Stark	0	11	3	....	0.3	0.1	33.1
Warren	0	14	9	....	0.4	0.2	38.5
Winfield	0	14	16	....	0.6	0.7	23.3
Total	785	1,383	1,023	0.5	1.0	0.7	1,431.5
Jefferson County							
Peripheral section							
Adams	....	2	0	....	tr	....	43.0
Alexandria	....	0	2	....	....	tr	72.8
Antwerp	....	15	18	....	0.1	0.2	109.0
Brownville	....	0	0	....	....	....	60.0
Cape Vincent	....	2	1	....	tr	tr	57.2
Champion	....	0	0	....	....	....	44.0
Clayton	....	0	0	....	....	....	80.1
Ellisburg	....	7	5	....	0.1	0.1	85.4
Henderson	....	7	3	....	0.2	0.1	44.1
Hounsfield	....	0	0	....	....	....	46.0
LeRoy	....	7	2	....	0.1	tr	75.0
Lorraine	....	11	10	....	0.3	0.3	40.0
Lyme	....	0	0	....	....	....	57.3
Orleans	....	0	0	....	....	....	73.6
Pamelia	....	0	1	....	....	tr	35.7
Philadelphia	....	0	0	....	....	....	38.6
Rodman	....	9	4	....	0.2	0.1	42.6
Rutland	....	0	0	....	....	....	46.0
Theresa	....	11	9	....	0.2	0.1	66.3
Watertown	....	0	0	....	....	....	36.9
Wilna	....	7	22	....	0.1	0.3	77.1
Worth	....	56	29	....	1.3	0.7	43.6
Total	29	134	106	tr	0.1	0.1	1,274.3

TABLE 2. (*continued*)

Section and town	Number taken			Number taken per square mile			Land area*
	1941	1954	1957	1941	1954	1957	
Lewis County							
Peripheral section							
Croghan	81	151	133	0.4	0.8	0.7	182.8
Denmark	0	0	1	....	....	tr	51.3
Diana	105	112	134	0.8	0.8	1.0	138.8
Greig	67	77	119	0.7	0.8	1.3	94.9
Harrisburg	0	3	16	....	0.1	0.4	39.8
Highmarket	41	38	18	0.7	0.6	0.3	62.7
Lewis	12	7	6	0.2	0.1	0.1	66.3
Leyden	0	4	9	....	0.1	0.3	34.0
Lowville	7	7	0	0.2	0.2	....	37.4
Lyonsdale	47	92	93	0.7	1.3	1.3	70.4
Martinsburg	10	9	12	0.1	0.1	0.2	76.2
Montague	27	27	3	0.4	0.4	tr	65.2
New Bremen	3	9	10	0.1	0.2	0.2	55.6
Osceola	38	79	48	0.4	0.9	0.6	87.0
Pinckney	4	3	4	0.1	0.1	0.1	41.9
Turin	0	7	6	....	0.2	0.2	32.4
Watson	66	118	90	0.6	1.0	0.8	114.9
West Turin	0	0	0	....	....	....	39.7
Total	508	743	702	0.4	0.6	0.5	1,291.5
Oneida County							
Peripheral section							
Annsville	....	10	12	....	0.2	0.2	59.8
Augusta	....	7	0	....	0.3	....	27.8
Ava	....	9	3	....	0.2	0.1	37.7
Boonville	....	21	51	....	0.3	0.7	71.3
Bridgewater	....	33	39	....	1.4	1.6	24.4
Camden	....	18	15	....	0.3	0.3	52.5
Deerfield	....	0	0	....	....	....	33.9
Florence	....	22	34	....	0.4	0.6	55.9
Floyd	....	7	17	....	0.2	0.5	35.2
Forestport	....	109	73	....	1.4	0.9	77.4
Kirkland	....	5	0	....	0.1	....	33.5
Lee	....	5	0	....	0.1	....	45.6
Marcy	....	0	0	....	....	....	33.3
Marshall	....	17	1	....	0.5	tr	32.4
New Hartford	....	1	0	....	tr	....	24.5
Paris	....	15	6	....	0.5	0.2	31.7
Remsen	....	12	22	....	0.3	0.6	36.2
Rome City	....	8	5	....	0.1	0.1	77.1
Sangerfield	....	30	31	....	1.0	1.0	29.9
Steuben	....	3	10	....	0.1	0.2	42.1
Trenton	....	1	0	....	tr	....	43.5
Vernon	....	3	0	....	0.1	....	38.5
Verona	....	5	0	....	0.1	0.1	70.0
Vienna	....	27	35	....	0.4	0.5	63.3
Western	....	13	12	....	0.2	0.2	55.5
Westmoreland	....	0	0	....	....	....	43.7

TABLE 2. (*continued*)

Section and town	Number taken			Number taken per square mile			Land area*
	1941	1954	1957	1941	1954	1957	
Peripheral section (*cont'd.*)							
Whitestown	....	1	0	....	tr	....	24.8
Total	141	382	372	0.1	0.3	0.3	1,199.5
Oswego County							
Peripheral section							
Albion	....	17	16	....	0.4	0.3	48.3
Amboy	....	22	15	....	0.6	0.4	37.7
Boylston	....	10	16	....	0.3	0.4	39.6
Constantia	....	54	50	....	0.9	0.9	57.9
Granby	....	5	1	....	0.1	tr	45.1
Hannibal	....	3	6	....	0.1	0.1	45.4
Hastings	....	1	10	....	tr	0.2	46.0
Mexico	....	3	0	....	0.1	....	44.6
Minetto	....	0	0	....	....	....	6.0
New Haven	....	1	8	....	tr	0.3	31.4
Orwell	....	24	13	....	0.6	0.3	42.2
Oswego	....	5	1	....	0.2	tr	27.8
Palermo	....	0	3	....	....	0.1	40.8
Parish	....	10	18	....	0.2	0.4	42.5
Redfield	....	83	61	....	0.9	0.6	94.2
Richland	....	9	3	....	0.2	0.1	50.4
Sandy Creek	....	1	1	....	tr	tr	43.0
Schroeffel	....	0	5	....	....	0.1	42.4
Scriba	....	1	1	....	tr	tr	41.2
Volney	....	1	5	....	tr	0.1	49.3
West Monroe	....	17	6	....	0.5	0.2	34.2
Williamstown	....	8	22	....	0.2	0.6	39.6
Total	175	275	261	0.2	0.3	0.3	949.6
St. Lawrence County							
Central section							
Clare	163	404	281	1.6	4.1	2.8	98.8
Clifton §	183	532	340	1.3	3.8	2.4	140.0
Colton §	229	605	477	0.9	2.4	1.9	254.1
Fine §	162	322	256	0.9	1.9	1.5	171.6
Hopkinton	131	235	256	0.7	1.2	1.4	188.3
Parishville	66	154	129	0.7	1.5	1.3	101.3
Piercefield	223	213	282	2.1	2.0	2.6	106.8
Pierrepont	4	35	36	0.1	0.6	0.6	61.2
Russell	61	52	96	0.6	0.5	1.0	97.3
Peripheral section							
Brasher	4	30	31	tr	0.3	0.3	92.4
Canton	4	3	8	tr	tr	0.1	106.9
DeKalb	0	4	2	....	tr	tr	83.6
DePeyster	0	1	1	....	tr	tr	43.9
Edwards	14	30	13	0.3	0.6	0.3	50.9
Fowler	8	15	21	0.1	0.2	0.3	60.2
Gouverneur	0	0	6	....	....	0.1	71.5

TABLE 2. (*continued*)

Section and town	Number taken			Number taken per square mile			Land area *
	1941	1954	1957	1941	1954	1957	
Peripheral section (*cont'd.*)							
Hammond	0	4	1	....	0.1	tr	64.0
Hermon	1	12	8	tr	0.2	0.1	54.3
Lawrence	4	1	16	0.1	tr	0.3	48.0
Lisbon	0	1	12	....	tr	0.1	109.9
Louisville	3	12	15	0.1	0.2	0.3	59.6
Macomb	0	4	5	....	0.1	0.1	64.5
Madrid	1	1	4	tr	tr	0.1	53.4
Massena	0	4	3	....	0.1	0.1	51.9
Morristown	1	0	0	tr	....	....	45.8
Norfolk	1	1	5	tr	tr	0.1	57.7
Oswegatchie	3	9	6	tr	0.1	0.1	69.2
Pitcairn	23	45	59	0.4	0.7	1.0	60.4
Potsdam	0	1	1	....	tr	tr	105.1
Rossie	0	3	3	....	0.1	0.1	39.0
Stockholm	3	12	15	tr	0.1	0.2	96.4
Waddington	0	9	13	....	0.2	0.2	57.0
Total	1,292	2,754	2,401	0.5	1.0	0.9	2,772.0
Saratoga County							
Peripheral section							
Ballston	....	1	0	....	tr	....	29.4
Charlton	....	3	0	....	0.1	....	32.9
Clifton Park	....	3	5	....	0.1	0.1	49.0
Corinth	....	18	20	....	0.3	0.4	55.9
Day	....	55	43	....	0.9	0.7	61.6
Edinburg	....	30	31	....	0.5	0.5	60.7
Galway	....	0	2	....	....	tr	44.3
Greenfield	....	18	17	....	0.3	0.3	67.0
Hadley	....	14	16	....	0.3	0.4	41.5
Halfmoon	....	1	0	....	tr	....	32.3
Malta	....	8	0	....	0.3	....	27.5
Milton	....	1	0	....	tr	....	35.7
Moreau	....	11	9	....	0.3	0.2	42.0
Northumberland	....	1	3	....	tr	0.1	31.8
Providence	....	19	13	....	0.4	0.3	45.9
Saratoga	....	1	5	....	tr	0.1	39.9
Stillwater	....	7	13	....	0.2	0.3	41.4
Waterford	....	0	0	....	....	....	6.4
Wilton	....	0	10	....	....	0.3	35.3
Total	159	191	187	0.2	0.2	0.2	780.5
Warren County							
Central section							
Johnsburg	155	132	126	0.8	0.7	0.6	202.2
Peripheral section							
Bolton	12	31	31	0.2	0.5	0.5	63.5
Caldwell	6	3	11	0.2	0.1	0.4	28.9
Chester	23	34	58	0.3	0.4	0.7	87.3

TABLE 2. (*continued*)

Section and town	Number taken			Number taken per square mile			Land area*
	1941	1954	1957	1941	1954	1957	
Peripheral section (*cont'd.*)							
Hague	10	23	10	0.2	0.4	0.2	64.9
Horicon	36	41	25	0.5	0.6	0.4	66.9
Luzerne	8	9	7	0.2	0.2	0.1	52.3
Queensbury	5	7	24	0.1	0.1	0.4	64.6
Stony Creek	100	68	88	1.2	0.8	1.0	85.4
Thurman	45	44	40	0.5	0.5	0.4	96.2
Warrensburg	12	22	31	0.2	0.3	0.5	67.5
Total	412	414	451	0.3	0.3	0.3	1,539.2
Washington County							
Peripheral section							
Argyle	....	7	6	....	0.1	0.1	56.9
Cambridge	....	18	27	....	0.5	0.7	36.1
Dresden	....	30	40	....	0.5	0.7	55.7
Easton	....	4	9	....	0.1	0.1	61.4
Fort Ann	....	61	101	....	0.6	0.9	109.0
Fort Edward	....	0	4	....	....	0.2	24.0
Granville	....	14	13	....	0.3	0.3	54.7
Greenwich	....	7	12	....	0.2	0.3	43.2
Hampton	....	25	24	....	1.1	1.0	23.2
Hartford	....	3	3	....	0.1	0.1	43.0
Hebron	....	25	41	....	0.5	0.7	54.7
Jackson	....	27	30	....	0.7	0.8	37.5
Kingsbury	....	0	2	....	....	0.1	38.4
Putnam	....	8	12	....	0.2	0.4	32.7
Salem	....	94	90	....	1.9	1.8	50.1
White Creek	....	60	44	....	1.3	0.9	46.7
Whitehall	....	19	45	....	0.3	0.8	55.9
Total	157	402	503	0.2	0.5	0.6	823.2

* In square miles of land area, but not including cities and villages.
§ Towns, some part of which was included in the wilderness tracts where hunting for antlerless deer was permitted in 1954.

adult does as the number of bucks taken by hunters. This is true because losses from predation are about equal for the two sexes among fawns and about proportional to the sex ratio among adults. The population would increase if the added losses among adult does did not occur.

5. In areas where starvation losses occur, they are a major known cause (other than illegal hunting) of greater mortality of females than males among adult deer. Among fawns, about 80 to 90 males die for each 100 females.

In the central Adirondacks, deer populations are relatively large. They exceed the carrying capacity of the majority of wintering areas. Some localities that are readily accessible do not have more deer than the winter range will support, but these are a minority. The winter range is very small in relation to the total land area, and most of it is severely overbrowsed. Mortality from starvation is common and occurs to some degree during the majority of winters. Winters with heavy losses occur more often than winters with negligible losses. The major factors that reduce abundance are illegal hunting, starvation and predation. The population increases when winters are mild or moderate for deer and the losses are negligible or low. The population fails to change or decreases when losses are heavy or severe.

Because of the present limit to the carrying capacity of the winter range, no sustained increase in the deer population is to be expected. However, a greater proportion of the bucks could be taken by hunting each fall. More hunters, a more uniform dispersal of them, and deeper penetration of remote areas would help to achieve this. And in most localities proper management should include harvesting does and fawns, as well as bucks. This would provide the greatest opportunity for the take to approximate the number produced annually and to reduce the losses from illegal hunting and starvation. Management in this area should also include a program to maintain, develop and expand the winter habitat. Increases in abundance are not possible until the area of winter range has been expanded or a great increase occurs in the available natural food supply in wintering areas. Because conifers are an important component of good wintering areas, real increases in the deer population are unlikely until substantially more coniferous shelter has become established. In the long run these two procedures, i.e., (1) proper harvest of the population and (2) maintaining, developing and expanding wintering areas, are the keys to the future of the deer population of the central section.

In the peripheral Adirondacks, deer populations are relatively small. They are, in most localities, far below the carrying capacity of the areas they occupy in winter. Mortality from starvation is relatively uncommon. The major factors that reduce abundance are illegal hunting and occasionally predation. The deer range of the section is in good condition generally. Substantial increases in abundance are possible if losses among does can be substantially reduced.

The data in Table 2 afford some indication of the deer population that the peripheral section might support. Virtually all of this section, except for the Tug Hill area in Lewis County, could support a deer population that would produce an annual legal harvest of 0.5 bucks per square mile of land area, and many of the towns should produce 1.0 to 1.5 bucks per square mile. Examples indicative of this potential are:

for Essex County: Moriah and North Hudson in 1941
for Franklin County: Bangor, Belmont and Brandon in 1954
for Fulton County: Stratford in 1957
for Hamilton County: Hope in 1957
for Herkimer County: Winfield in 1957
for Jefferson County: Worth in 1957
for Lewis County: Diana and Greig in 1957
for Oneida County: Bridgewater and Forestport in 1954 and 1957
for Oswego County: Constantia and Redfield in 1954
for St. Lawrence County: Pitcairn in 1954 and 1957
for Saratoga County: Day in 1954
for Warren County: Stony Creek in 1941
for Washington County: Fort Ann, Hampton, Salem and White Creek in 1957

Although the high levels reached in these and other towns were not sustained, they represent populations that were still very largely within the carrying capacity of the range. They illustrate what could take place more generally in the peripheral section if the illegal kill, particularly of does, could be significantly reduced.

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EXPERIMENTAL ESTABLISHMENT OF CERTAIN WILDLIFE FOOD PLANTS BY GRAFTING[1]

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ABSTRACT

Attempts were made to establish certain crab apple, apple, pear and hawthorn cultivars by grafting them onto wild apple or hawthorn trees and by planting a few that could be purchased as small trees. The object was to obtain early establishment and fruiting to provide winter food for wildlife. Grafting by top-working proved to be the most practical method on the basis of cost, ease of establishment, rapid fruiting, and freedom from wildlife damage.

As part of a program of testing a number of plants for their value as winter foods for wildlife, the problem arose as to how to get a number of kinds (or cultivars[2]) of apples established and to the fruiting stage rapidly without substantial damage to the young plants by mice, woodchucks, rabbits or deer. This hazard is particularly acute in the case of young apple trees, so that orchardists have long resorted to various protective devices, such as a layer of stones or cinders about the base of the plant, wrapping the trunks with protective paper, surrounding the trunks with a ring of tar paper or hardware cloth, or applying protective washes or sprays. In orchards it is also necessary to control the numbers of mice and rabbits.

Since the experimental plantings were designed for upland game management areas where intensive culture and annual rodent control would not be carried on, another method of establishment had to be sought for the apples. In addition, many of the apples to be tested existed as single trees, and since only a few cultivars could be obtained from any source, commercial or private, it was decided to resort to grafting procedures to get them established where wildlife species could have an opportunity to use their fruits for food.

METHODS

The site chosen for the experimental grafting work was the Partridge Run Game Management Area, a public hunting area in the town of Berne in southwestern Albany County. Elevations range from 1,200 feet to nearly 2,000 feet above sea level. Soils are thin, poorly drained and lacking in fertility (Lounsbury *et al.*, 1942).

Because of the great number of naturalized apple trees, in all stages of growth, that could be found in the abandoned pastures, hedgerows

[1] A contribution of Federal Aid in Fish and Wildlife Restoration Project W-88-R. Acknowledgement is made of the courtesy of Bernard Harkness of the Rochester Department of Parks and Recreation and Donald Wyman of the Arnold Arboretum in permitting the taking of scion wood from the plantings under their jurisdiction.

[2] A cultivar is an individual plant whose desirable characteristics can only be perpetuated by vegetative propagation (grafting or budding). The Cortland apple is a cultivar, and all Cortland apple trees are really pieces of the same, original tree.

and fields on the area, it was decided to use these as understocks onto which the cultivars of apple could be grafted by top-working onto the uppermost stems, employing the simple cleft graft (Garner, 1947). Scion wood of the various cultivars was obtained from two principal sources, the Rochester (N. Y.) park system and the Arnold Arboretum at Jamaica Plain, Massachusetts. Other scion wood was obtained from various sources. Grafting was started in late March and continued until the buds on the apple trees began to burst in late April or early May.

In general, the understock trees were chosen for their apparent vigor, freedom from disease or injury, and suitable size and branching. Stems 1 to 3 inches in diameter were preferred because larger stems were difficult to split. Branches near the top of the tree were chosen to get control of the tree by the scions as soon as possible. Usually, a minimum of two scions was added, but in some cases as many as 16 were added to a single tree. Side branches were left to help draw the sap to the top of the tree; these had to be removed in the spring following the original grafting to prevent their assuming command of the tree.

When scions failed to grow, if the understock remained alive, two methods were tried to make up for the loss. In late August or early September the same cultivar was used to add budwood to the numerous sucker shoots or watersprouts near the ends of the branches which had been cut off for grafting. In the following spring, if the buds had united with the watersprouts, the latter were cut back to a point just above the inserted bud to force growth into the bud. The second method was to rework the stems in the following spring, by cutting back the dead ends and regrafting.

Each tree was revisited once during the first growing season to check on condition of the grafts and to remove any competing watersprouts, and again during the second growing season to remove the competing branches and to do any necessary shaping of the grafts.

In all, 83 different cultivars of apple, most of them in the crab apple class, three of hawthorn and one of pear, were used in grafting onto 665 different trees between 1957 and 1961 (see Table 1). The cultivar used on each tree was identified by a temporary, wooden plant tag on which was recorded the identifying number and name, and the year. When grafts were determined to be established, an embossed stainless steel identifying tag was added. Any competing plants that had not been removed at the time of the original grafting were then removed.

For comparison, small numbers of crab apple cultivars were purchased as small trees and set out in small orchards on the same area each year. These were planted by means of pick and shovel and were fertilized and mulched with old cow manure. Each stem was protected by either a wrapping of expanded aluminum foil or a ring of ¼-inch-mesh hard-

ware cloth. In addition, some of the trees were protected from deer by a ring of 1 x 2-inch-mesh electrically welded fencing, 3 feet in diameter and 4 feet high, to permit the branches to expand.

In 1959, a variation of grafting was tried whereby five small apple trees, 1½ to 3 inches in diameter at the ground level, were cut back to within a few inches of the ground so that grafting could be done. The scions were then protected with a cylinder of ¼-inch-mesh hardware cloth, which was held in place by a length of No. 9 gauge wire passed through the base of the cylinder and anchored at the ends by flat stones. In 1960, 17 more trees were so grafted, and in 1961, nine additional grafts were attempted using this method.

FINDINGS

Results of the attempts at grafting by top-working are shown in Table 1. Identity of the cultivars is shown by either the species name or the cultivar name, followed by an identification number. Scion wood was applied to 665 trees, although this figure is somewhat deceptive because trees on which grafting was a failure, but which remained in good condition, were usually reworked the following spring and not always with the same cultivar.

The rate of grafting success in 1957 was very poor because of inexperience in the grafting process, including use of too small scions, improper placing and fit of scions, grafting too late in the season when weather was too warm, too severe pruning of the understock which resulted in the death of whole branches or entire trees, and selection of trees in poor growing condition. In 1957, 35 trees were killed as a result of grafting attempts.

In 1958, only 10 trees were killed, but grafting too late in the season and holding scion wood too long in storage apparently caused the uniform failure of the last 14 grafting attempts.

In 1959, grafting success was very good, apparently because of more careful selection of understock trees and more careful attention to fit of scions and understock. It was found that workers could be shown in a few hours' time how to select trees carefully and make successful grafts.

Certain evidence of incompatibility of understock and scion wood appeared. Cultivars of *Malus sargenti*, a dwarf crab apple, which had grown slowly, began to die back. Scions of one hawthorn (Crataegus No. 1), which apparently had united well with the understock and had grown vigorously, suddenly broke off cleanly at the union of the graft. Scions of a cultivar named Adams (#873-50) grew vigorously for a season, then suddenly shrivelled and died, which is indicative of the presence of a virus either in the understock or the scion wood.

One important contrast appeared between the crab apples, which originated in Asia, and the common apple cultivars in the speed with which the former produced flowers and fruits. Well grown grafts of the

TABLE 1. RESULTS OF EXPERIMENTAL GRAFTING OF CRAB APPLE AND APPLE CULTIVARS AT THE PARTRIDGE RUN GAME MANAGEMENT AREA, 1957–1961

Cultivar	Identity number	Number of trees worked and number on which grafts were successful										Subsequent losses	Trees surviving to 1962*
		1957		1958		1959		1960		1961			
		Trees	Grafts successful	Trees	Grafts successful	Trees	Grafts successful	Trees	Grafts successful	Trees	Grafts successful		
Crab apples and apples													
Species of *Malus*													
arnoldiana	831	...	...	3	2	...	...	...	...	...	...	0	2
arnoldiana	3488	...	...	...	...	...	...	1	1	...	...	0	1
arnoldiana	3490	...	...	5	5	...	...	3	3	...	...	2	6
atrosanguinea	317	...	...	...	...	2	0	...	...	...	...	0	0
baccata jacki	904	...	...	2	0	...	...	7	6	...	...	1	5
baccata mandshurica	4051	3	1	3	2	...	...	...	...	...	...	0	3
dawsoniana	3461	...	...	2	1	1	1	2	2	5	4	5	3
dawsoniana	3491	1	1	...	...	3	3	5	5	...	...	2	7
ellwangeriana	266	...	...	...	...	2	0	...	...	...	...	0	0
ellwangeriana	271	...	...	2	0	...	...	...	...	...	...	0	0
floribunda	1704	...	...	2	1	3	1	...	...	...	...	1	1
floribunda	890	...	...	...	...	4	1	...	...	...	...	0	1
floribunda	3433	1	1	6	4	...	...	...	...	...	...	0	5
floribunda	3988	...	...	...	...	2	0	...	...	...	...	0	0
hupehensis	811	...	...	8	4	...	...	...	...	...	...	3	1
hupehensis	832	...	...	2	2	...	...	...	...	...	...	0	2
hupehensis	843	7	1	3	1	...	...	...	...	...	...	0	2
hupehensis	3449	...	...	...	...	...	...	2	2	...	...	1	1

hupehensis	17448	6	0	7	4	5	5			2	1	0	10
hupehensis	20414-B			6	2							0	2
prunifolia rinki	516	4	1									0	1
prunifolia rinki	4645	8	6	2	1							0	7
prunifolia xanthocarpa	4005			7	4	2	2	2	2			4	4
pumila "Niska Gold"				2	1	12	12	2	2			1	14
pumila "Niska Nugget"		5	4	1	1	3	3	5	5			3	10
pumila	Cook #1					3	3					0	3
pumila	Cook #2					5	5					0	5
pumila	Cook #3					1	1					0	1
pumila	Cook #4					2	2					0	2
pumila	Cook #5					3	3					0	3
pumila	Maunton #1					5	4					0	4
purpurea	Shultes					2	2	1	1			0	3
purpurea	3529					3	2					0	2
purpurea	3535			6	5							3	2
robusta	22338-C	12	3	4	3	2	2			6	6	0	14
robusta	22665	9	4	2	0	15	14					5	13
robusta	23088									3	3	2	1
robusta	33985			1	1	3	3	4	4	3	3	1	10
robusta costata	3447					4	4					0	4
robusta costata	3451			2	2	3	3	2	1			0	6
robusta persicifolia				8	3							0	3
sargenti	734			3	1							0	1
sargenti	925	6	4	5	4	4	4					1	11
sargenti	3456	1	1	4	1	7	2					0	4
sargenti	4581-5-C					2	2					0	2
sargenti	20408	11	2	1	0							2	0
sargenti	Slavin #2			6	4	6	6					1	9
sieboldi	3436					5	3					0	3
sieboldi	4075	3	1									0	1
sikkimensis	56-36-A					5	5			7	7	0	12
sikkimensis	856			3	3							0	3
sikkimensis	4093	2	1									0	1
spectabilis riversi	3429									1	1	0	1
spectabilis	4094			3	3							0	3
toringoides	177-37-D					3	3					0	3

Table 1. (*continued*)

Cultivar	Identity number	Number of trees worked and number on which grafts were successful										Subsequent losses	Trees surviving to 1962*
		1957		1958		1959		1960		1961			
		Trees	Grafts successful	Trees	Grafts successful	Trees	Grafts successful	Trees	Grafts successful	Trees	Grafts successful		
Species of *Malus* (*cont'd.*)													
toringoides	177-37-E	10	1	...	...	...	...	...	...	...	...	0	1
zumi	22707-A	10	7	1	1	...	...	...	...	...	...	1	7
zumi	22707-B	...	...	3	2	...	...	...	...	...	...	0	2
zumi calocarpa	329	1	1	...	...	6	6	...	...	...	...	0	7
zumi calocarpa	576	...	...	5	1	...	...	...	...	...	...	0	1
zumi calocarpa	580	4	2	2	1	...	...	...	...	...	...	1	2
zumi calocarpa	20404-C	...	...	9	2	...	...	...	...	...	...	1	1
Cultivars (named)													
Adams	873–50	...	...	4	0	8	5	...	...	2	2	3	4
Bobwhite	20367	32	16	10	8	4	3	3	3	...	...	4	26
Eleyi	.....	...	...	...	...	3	3	...	...	...	...	0	3
Gibbs Golden Gage	.....	...	...	2	1	...	...	...	...	...	...	0	1
Liset	.....	...	...	1	1	...	...	...	...	...	...	0	1
Morden 457	.....	...	...	3	3	...	...	...	...	...	...	2	1
Oakes	.....	...	...	9	1	...	...	...	...	...	...	0	1
Ormiston Roy	.....	...	...	5	4	...	...	...	...	...	...	1	3
Profusion	338–50	5	2	2	1	3	3	5	5	...	...	0	11
Winter Gold	339–50	...	...	2	2	...	...	...	...	1	1	0	3
Cultivars (unnamed)													
.....	434	2	1	3	2	4	4	3	3	1	1	0	11

.....	532–48	...	...	...	...	2	1	...	...	4	3	1	3
.....	22800-B	...	...	2	2	...	...	...	...	2	1	0	3
.....	23029-A	11	3	1	1	16	16	8	8	...	...	9	19
.....	23029-B	...	...	...	...	5	5	...	...	5	5	0	10
.....	23029-D	...	...	...	...	...	...	...	...	6	6	1	5
Hale seedling.....	.....	6	5	...	...	...	...	...	...	...	...	2	3
.....	1935W	...	...	2	1	...	...	...	...	...	...	0	1
.....	59–1	...	...	...	...	3	3	...	...	...	...	0	3
.....	300	...	...	...	...	...	...	1	1	...	...	0	1
.....	301	...	...	...	...	...	...	3	3	...	...	0	3
Unknown (tags lost)...	.....	14	0	...	...	...	...	...	...	...	...	...	0

Other

Pyrus calleryana.....	3411	1	1	...	...	...	...	...	...	...	...	0	1
Crataegus sp.....	#1	4	1	7	5	1	0	...	...	...	...	5	1
Crataegus sp.....	#2	4	2	4	0	...	...	...	...	...	...	0	2
Crataegus sorbifolia.....	15291	...	...	...	...	7	7	...	...	4	4	3	8
Total.....		183	73	188	104	184	157	59	57	52	48	72	367
Percentage of trees on which grafts successful after 1 year.....		39.9		55.3		85.3		96.6		92.3		...	...

* Total trees worked..... 665
Initial losses..... 226
Initial successes..... 439
Subsequent losses..... 72
Trees surviving to 1962..... 367
Percentage of success.....55.2

crab apples started flowering the first year after being grafted and continued to fruit abundantly in subsequent seasons. Scions of *Malus pumila* "Nugget" and *Malus pumila* "Gold", from seedlings of two common apples in the crab apple size class, were used along with some commercial apple cultivars on a small scale in the spring of 1956 as a preliminary trial of this method. These selections of the common apple grew very vigorously, but they did not flower at all until 1959 and produced no fruits until 1960.

The attempts at reworking the grafting failures by adding buds to the watersprouts in late summer were highly successful so far as getting the buds to unite with the understock, but a pruning operation was required in the following spring, plus at least two subsequent pruning operations to eliminate competing watersprouts and to establish the dominance of the desired growth. This method, therefore, was discontinued in favor of reworking the understocks in the following spring.

Attempts at establishing cultivars by grafts placed practically at ground level yielded some success (Table 2), with shoot elongations of from 4 to 8 feet in two growing seasons. The need for complete protection of such stems from mice, woodchucks and rabbits for many years, plus the fact that no stem reached the flowering stage in three seasons, seemed to offset the advantage of a ready-made, well established root system.

The small, orchard-type plantings of purchased crab apple plants grew very poorly. The best of planting sites on the Partridge Run Game Management Area are usually sodden wet in the spring because of poor drainage, so that apples become established only with difficulty. The expanded aluminum foil failed to protect the stems from mouse, rabbit or woodchuck injury, and when the snow depth exceeded the height of the hardware cloth guards both mice and rabbits were able to injure the exposed wood severely. Any foliage within reach of deer was browsed severely in early summer, until about the middle of July, when the deer began to feed on herbaceous materials.

Cost records were kept for comparative purposes. To graft a tree by top-working involved getting scion wood, although on several occasions enough for an entire season's work was provided to the project without cost. In the case of a cultivar like "Nugget", collecting the first scions required 3 hours of labor (at \$1.80 = \$5.40) and 46 miles of travel (at 8¢ = \$3.68) to produce 100 scions, i.e., approximately 9¢ each or 36¢ for the number needed for an average grafting operation. In subsequent years it was found possible to take scion wood directly from the previous season's successful grafts, so that the only cost was for the time to collect the scion wood. It was found that one man could locate, brush out, prune, graft, and label a tree every half hour. It took up to two subsequent visits (total time half an hour) to prune, shape, relabel

TABLE 2. RESULTS OF LOW GRAFTS OF CRAB APPLE CULTIVARS AT THE PARTRIDGE RUN GAME MANAGEMENT AREA, 1959–1961

Cultivar	Identity number	1959		1960		1961	
		Trees	Grafts successful	Trees	Grafts successful	Trees	Grafts successful
Species of *Malus*							
baccata jacki	904	..	..	1	1	..	..
dawsoniana	3461	4	3	1	1	..	..
dawsoniana	3491	2	1	1	1	..	..
hupehensis	17448	..	..	1	1	..	..
prunifolia xanthocarpa	4005	4	1	3	3	..	..
pumila "Niska Nugget"	.....	..	..	1	1	..	..
robusta	23088	..	..	..	..	3	1
robusta	22338-C	..	..	..	..	6	0
robusta costata	3451	..	..	1	1	..	..
Cultivar (named)							
Bobwhite	20367	..	..	3	3	..	..
Profusion	338–50	..	..	3	3	..	..
Cultivar (unnamed)							
.....	434	..	..	2	2	..	..
Total	.....	10	5	17	17	9	1

and release the tree. Over-all cost, therefore, was about $2.00 per tree after the first year.

Purchased, named cultivars of crab apples cost from 90¢ to $1.65 per tree, averaging $1.44. Packing and transportation added 15¢ per tree for a total purchase cost of $1.59. It took two men approximately 15 minutes to plant a tree, another 15 minutes to cut a wire guard and put it into place, and another 15 minutes to haul and apply manure, i.e., a total time of an hour and a half or $2.70 per tree. The trunk guards cost 30¢ apiece, while wire fence cylinders to hold back deer cost $3.00 each. Total cost per tree was approximately $7.59.

DISCUSSION

The advantages of using the top-working method of establishing crab apples are readily apparent. Use is made of relatively small apple trees that have established root systems under adverse soil and moisture conditions, whereas "own-root" plants must become established before they can fruit well. The naturalized understocks have the roughened bark that under all but the most extreme conditions prevents mice, woodchucks and rabbits from girdling the trees and destroying the tops. Selection of branches for grafting that are above the summer reach of deer prevents browsing losses. The crab apples generally start fruiting in the second season after grafting, so that observations on their use can

be made sooner. Derivatives of the common apple do take 3 to 5 years to form flower buds, but this is still more rapid than for planted trees.

Failures of grafting attempts were great during the first two seasons, but this is chargeable to lack of experience of the workers in the grafting technique and in the selection of suitable wild trees to be grafted.

There are a number of disadvantages to the use of purchased plants. Only a few cultivars are obtainable commercially, so that grafting must be used to get any plants at all of some cultivars that exist as single trees. The commercial plants grow well in good soils, but they all grew poorly in the Partridge Run soils in spite of fertilization. The small diameters of the stems and the smooth bark, plus the fact that the commercial plants had grown in fertile soil, make them attractive to mice, woodchucks and rabbits so that protection was necessary. Protection of the foliage from deer is also necessary until the trees can be pruned up out of reach.

Some attention needs to be given to the problems of incompatibility and disease between understocks and scion wood. If scion wood or commercially produced plants are to be planted in or near commerical orchards, attention should be given to insuring that all material is virus-free. As a matter of sound practice, no virus-infected material should be used anywhere.

CONCLUSIONS

It was found that crab apple cultivars could be established rapidly and at reasonable cost by top-working them onto already established, volunteer apples in the old pastures on the Partridge Run Game Management Area. Fruiting could be expected to start for crab apples the first year after establishment, and for derivatives of the common apple from 3 to 5 years after being grafted. It was found difficult to establish "own-root" plants on the soils available, and it was necessary to protect these against mice, woodchucks, rabbits and deer for long periods thereafter.

While grafting losses were considerable during the first two seasons from lack of experience in grafting and in the selection of the wild trees to be worked, it was found that this knowledge could be acquired and that workers could be trained readily.

Graft incompatibilities were indicated for one hawthorn when worked onto wild trees and for the slow-growing Sargent crab when worked onto common apple. The cultivar "Adams" showed signs of being affected by virus, either self-borne or from the understock trees, so it should be used with caution until the source of the virus is identified.

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GENERAL NOTES

A STUDY OF THE ADEQUACY OF COBALT NUTRITION IN NEW YORK DEER

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New York State has known areas of cobalt deficiency, many of which are located in or adjacent to the Adirondack region. There is thus the possibility that growth and development of deer in the deficient areas may be limited by inadequate intakes of this trace mineral element. In domestic ruminant animals, a dietary deficiency of cobalt leads to a depressed appetite, anemia and subnormal production, including growth. Unfortunately, these symptoms can also occur due to a variety of other diseases, and thus they are not specific for cobalt deficiency. Cobalt functions primarily as a structural element in vitamin B_{12}. In the ruminant stomach, bacteria synthesize vitamin B_{12} from cobalt and other raw materials, and the vitamin thus becomes the metabolically active form of cobalt for animals. Non-ruminants have little ability to synthesize vitamin B_{12} and are thus dependent on a dietary supply of it. Under conditions of a dietary shortage of cobalt, the vitamin B_{12} reserves of the body decline and the observation of this decline specifically indicates a deficiency of cobalt. The liver, due to its high concentration of B_{12}, is the organ of choice for analysis.

The following preliminary survey was undertaken to assess the adequacy of the cobalt intake of sample populations of New York deer herds in Seneca, Herkimer, Chenango and a miscellaneous group of other counties by determining the vitamin B_{12} concentration in liver samples from hunter-collected deer.

REVIEW OF THE LITERATURE

A search of the literature revealed no data on the vitamin B_{12} concentration in deer liver samples and only limited data for other ruminant animals.

Mean values for beef and sheep livers were reported to range from 0.31 to 1.33 micrograms (μg) of vitamin B_{12} per gram of fresh liver (Aitken and Duncan, 1960;

TABLE 1. VITAMIN B_{12} CONCENTRATIONS IN LIVERS OF DEER FROM SPECIFIED AREAS IN NEW YORK

Area	Number of samples	Micrograms per gram		
		Fresh weight		Dry weight mean
		Range	Mean	
Seneca Ordnance Depot	19	0.35—1.87	1.00	3.70
Herkimer County	11	0.56—1.87	1.01	3.77
Chenango County	5	0.51—0.88	0.71	2.91
Miscellaneous*	6	0.80—1.22	1.01	3.80
Total	41	0.36—1.87	0.93	3.55

* Represents Broome, Franklin and Tompkins Counties. Samples from these areas were statistically analyzed as a composite since there were at the most only two samples from each and the values obtained were very comparable.

Table 2. Vitamin B_{12} Concentrations in Lamb and Beef Livers

Sample	Micrograms per gram	
	Fresh weight	Dry weight
Lamb 1	1.87	5.69
Lamb 2	1.87	6.20
Beef 1	0.99	3.74
Beef 2	0.62	2.11

Table 3. Statistical Analysis of Vitamin B_{12} Concentration in Deer Livers from Different Areas

Source	Degrees of freedom	Sum of squares	Mean square	Value o *F*
Treatment	3	3.0880	1.0293	0.68 (n.s.)
Error	37	55.7023	1.5055	
Total	40	58.7903		
Standard deviation		0.606		

Andrews *et al.*, 1958; Hockstra *et al.*, 1952; Koval'skii and Raetskaya, 1955; Lichtenstein *et al.*, 1959; Scheid and Schweigert, 1954; Shenoy and Ramasarna, 1954). Shenoy and Ramasarna (1954) reported a mean of 1.18 μg /g of fresh liver for beef cattle, 1.33 μg /g for sheep, and 1.20 μg /g for goats. Andrews *et al.* (1958) reported that livers taken from lambs on an adequate cobalt diet contained 0.39 to 1.1 μg /g of fresh liver, with a mean of 0.65 μg /g. These workers determined that a definite cobalt deficiency was associated with livers in which vitamin B_{12} concentration was less than 0.10 μg /g of fresh liver. Hockstra *et al.* (1952) noted that on diets essentially free of cobalt sheep had a liver vitamin B_{12} activity of 0.05 μg /g, whereas on a cobalt-supplemented diet the content was 0.93 μg /g of fresh liver. Our own observations (Kercher and Smith, 1956) have shown that lambs displaying a frank cobalt deficiency had a vitamin B_{12} liver concentration of about 0.05 to 0.07 μg /g of dry liver tissue. (Equivalents of vitamin B_{12} concentrations in fresh and dry liver tissue are included in Tables 1 and 2.)

Most of the concentrations here reported were determined by microbiological methods using either *Lactobacillus leichmannii* or *Ochromonas malhamensis*. Lichtenstein *et al.* (1959) compared the values obtained for beef livers using these two different microorganisms and found comparable values, i.e., 1.22μg /g of fresh liver using *Ochromonas* and 1.16 μg/g of fresh liver using *Lactobacillus*. The *Ochromonas* assay was used in this study because generally it has been shown to give the most accurate response to true vitamin B_{12} concentration (Ford, 1953).

PROCEDURE

Deer liver samples were obtained through the cooperation of hunters, guides and several New York State Conservation Department personnel. They were procured the day of the kill and frozen as quickly as possible, usually the same day. Homogenates were then made of these samples in a Waring blendor. Concentration determinations were made on the homogenates using an assay procedure which is a modification of that of Ford (1953). Optical density readings were obtained on a Beckman Model B spectrophotometer and compared with a standard of crystalline vitamin B_{12}. A 6-day incubation period was used, with the culture under showcase lights regulated to maintain a temperature of 28±3° C.

A completely random design was used to study the effect of geographical area on

the vitamin B_{12} concentration. The statistical computations were made on a dry matter basis to remove as much variation as possible due to difference in dehydration of the livers during storage.

Two lamb and two beef livers were obtained from the Cornell herd and assayed for vitamin B_{12} concentration under conditions comparable to the deer liver assays.

The vitamin B_{12} concentrations as determined for each area are presented in Table 1. The results of the assay of the two lamb and two beef livers are presented in Table 2. The statistical analysis of the results are included in Table 3.

DISCUSSION

As the summarized data in Table 1 show, there was great variation in the vitamin B_{12} concentration in the livers of deer within areas although the mean values among areas were remarkably uniform. There was some indication from these data that the vitamin B_{12} concentration varied directly with age inasmuch as the lowest concentrations in three of the four areas were obtained from fawn livers and the highest from mature deer.

The mean vitamin B_{12} levels observed here compare, at least roughly, with those reported in the literature for beef cattle, sheep and goats, and even the lowest individual values were appreciably higher than the level of 0.1 μg/g of fresh liver which is interpreted by Andrews *et al.* (1958) to indicate a cobalt deficiency. They are well above the vitamin B_{12} concentration of 0.05 to 0.07 μg/g of dry liver tissue which we found to be associated with a frank cobalt deficiency in lambs.

As summarized in the analysis of variance, there was no significant difference in the B_{12} concentration of livers of deer among the areas studied.

CONCLUSIONS

The vitamin B_{12} concentrations in the livers of 41 deer taken from three major areas in New York State did not differ significantly among each other and were roughly comparable to the levels observed in well-fed domestic ruminants. Even the lowest individual values gave no indication of a dietary deficiency of the element, cobalt.

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SOME NOTES ON THE SUMMER WHISTLING OF MALE BOBWHITE QUAIL

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Game farm quail were released on a 2,500-acre study area in westcentral Livingston County (N. Y.) in September of 1960 and 1961 in an experiment designed to determine whether or not the species could be reestablished in this formerly occupied range. In both instances, substantial numbers remained on the area at the end of the succeeding winter and good reproduction occurred in 1961. Considerable attention was given to the calling of both sexes during spring and summer in an effort to estimate the numbers of whistling males, to locate mated pairs and to estimate the numbers of unmated males that remained on the area in late summer.

In the late winter of 1961 the observed sex ratio favored males 125 : 100. Intensive whistling (six or more calls per minute continuing for periods of 8 to 10 minutes) was heard throughout the spring until about mid-May. The covey call was seldom heard.

In 1962 the corresponding sex ratio was 71 : 100 and favored hens. Intensive whistling by males was heard only infrequently during the spring, and the covey or "scatter" call was more often recorded. There were several observations of males moving toward birds voicing the covey call, and in one instance the calling bird was known to have been a hen.

It seems probable that in 1961 a greater number of males was attempting to attract a lesser number of hens, and that in 1962 the reverse was true, the hens announcing their presence to a lesser number of males by voicing the covey call.

Two types of whistling by males were noted during the summer (Table 1). Type 1 was definitely identified with an unmated male in one instance. This bird, easily identified by a peculiarity of voice, was seen twice within a 3-hour period on

TABLE 1. TYPES OF WHISTLING BEHAVIOR NOTED AMONG MALE BOBWHITE QUAIL

Characteristic	Type 1	Type 2
Frequency	Six or more calls per minute	Four or less calls per minute
Duration	8 to 10 minutes	2 minutes or less
Quality	Last note loud and piercing	Last note soft and subdued
Response to whistled covey call	Almost unfailing	Never observed
Mobility of bird	Up to ¼ mile in 3 hours	No significant movement noted

June 28, 1962 and was unaccompanied by a hen either time. The two observations were made at points only slightly more than ¼ mile apart, and the bird responded eagerly to a whistled covey call, flying in toward the observer both times. The latter behavior was recorded by Stoddard (1950) who found that unmated males responded readily to any crude imitation of the covey call.

No male known to be mated was identified with the Type 2 whistling pattern. However, the lack of movement, the close relation of the location to places where pairs had frequently been seen, the uniform failure to respond to a whistled covey call, and the lack of aggressiveness implied by the short duration and softness of the notes all suggest the satisfactorily mated male quail and his well known devotion to his mate.

It is believed that, under conditions of this kind, mated may be distinguished from unmated male bobwhite quail during spring and early summer on the basis of differences in whistling and related behavior.

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SIDE EFFECTS OF SUDAN BLACK B ON CARP AND MASS MARKING OF TROUT WITH THIS DYE[1]

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It has been reported (Loeb, 1961) that carp, trout and goldfish can be turned a deep blue by feeding the dye Sudan Black B (Solvent Black 3, Color Index No. 26150). The dye produced blue coloration of all tissues but tooth enamel and lasted in diminishing degrees for days to months depending on the dose ingested. It was also stated that carp were unaffected by the dye, an observation refuted by later experiments.

Additional experiments with Sudan Black B at the Fish Laboratory at Livingston Manor (N. Y.) were part of a program designed to produce long lasting, easily applied and harmless marks to fish. The tests showed that fish could be marked for many months by mass production techniques and that temperature affected the duration of the coloring. Thus far six species have been marked with Sudan Black B, and it is suspected that most species would be turned blue by the dye. Marked species include carp (*Cyprinus carpio*), goldfish (*Carassius auratus*), brook trout (*Salvelinus fontinalis*), brown trout (*Salmo trutta*), common shiner (*Notropis cornutus*) and creek chub (*Semotilus atromaculatus*). The dye is apparently harmful to some fish, however.

Carp were seriously affected by the dye over a period of months, although actual tissue changes are unknown. Nine carp were fed for six days as much food containing 2 per cent Sudan Black B as they would eat. All turned a deep blue. Four developed an ulcerated condition of the scales, especially along the lateral line, and also became extremely thin and emaciated. Appetites were not noticeably affected, but the fish died during the 3rd and 4th months after treatment and while still blue. One had developed a swelling in the right-rear portion of the head. The other five developed only the ulcerated scale condition which has persisted for 13 months at this writing. These fish, which have been held at a temperature of 65° F., retain the merest trace of blue coloration and are plump and active. Control fish held in the same tank throughout the experiment have shown no adverse symptoms. At this point it should be mentioned that dyed fingerling brook trout held at 65° F. also became emaciated but yearlings held at 47° F. did not. Possibly higher temperatures are a factor in producing adverse symptoms. This is merely suggested since experimental conditions are not complete.

Two experiments involving trout were performed to study mass marking possibilities and to determine the relative duration of blue coloration at different temperatures. Coloration lasted somewhat longer at lower temperatures. The possibilities of mass marking were well demonstrated. A biologist could, with a minimum of work, easily color thousands of trout merely by placing Sudan Black B in their food for several days.

For four days 69 yearling brook trout and 60 yearling brown trout were fed as much pork melts containing 1 per cent Sudan Black B as they would eat. All fish were held in the same 500-gallon tank at a constant temperature of 47° F. They were fed both fish pellets and meat, and they grew well. About one-third of the fish were lost during the period of experimentation. A few of each species jumped from the tank despite partial covers, while probably an equal number of the smaller fish were eaten (possibly the coloration of the larger fish was affected by this). Several individuals of each species died after several months for no apparent reason and these individuals were either slightly blue or had lost all coloration.

At the end of 3 months all of the brook trout and 91 per cent of the brown trout were still marked (several had coloration only in the mouth). After 4 months the percentages were 100 and 84, respectively, indicating that the dye was more effective on the brook trout, or that they had been the more aggressive feeders and thereby consumed more dye. After 5 months 95 per cent of the brook trout were still blue (most of them in the mouth only) while the proportion for brown trout had dropped to 49 per cent. Only 35 per cent of the brown trout were distinguishable after 6 months whereas 72 per cent of the brook trout were still blue. At 7½ months 33 per cent of the brook trout were blue in the mouth (the entire body of one fish was very blue) while the brown trout were largely colorless. The study indicates that mass marking with Sudan Black B could be used in field studies at low temperatures lasting for 7 to 8 months depending upon information desired.

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To determine the effect of higher temperature upon the duration of such coloration, 150 fingerling brook trout were marked in similar fashion to the yearlings and held at 67° F. for 5 months. A large number became emaciated after 3 to 4 months and died despite the fact that they ate well. One month after marking 98 per cent of these fish were blue; the figure was 90 per cent (a quarter of these in the mouth only) at 2 months, 81 per cent at 3½ months (mostly in the mouth) and 12 per cent at 5 months. The data show the possibility of using mass marking in field experiments of 3 to 4 months' duration with temperatures of about 65° F. Mortality might be a limiting factor at this temperature, however.

The tests show a need for less harmful dyes which will produce longer lasting marks. These undoubtedly exist, but considerable screening will be required to identify them. To date, only Plasto Pink (Loeb, 1962) has been found to cause quick coloration of fish when fed, but only for a few days and in carp, not trout.

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